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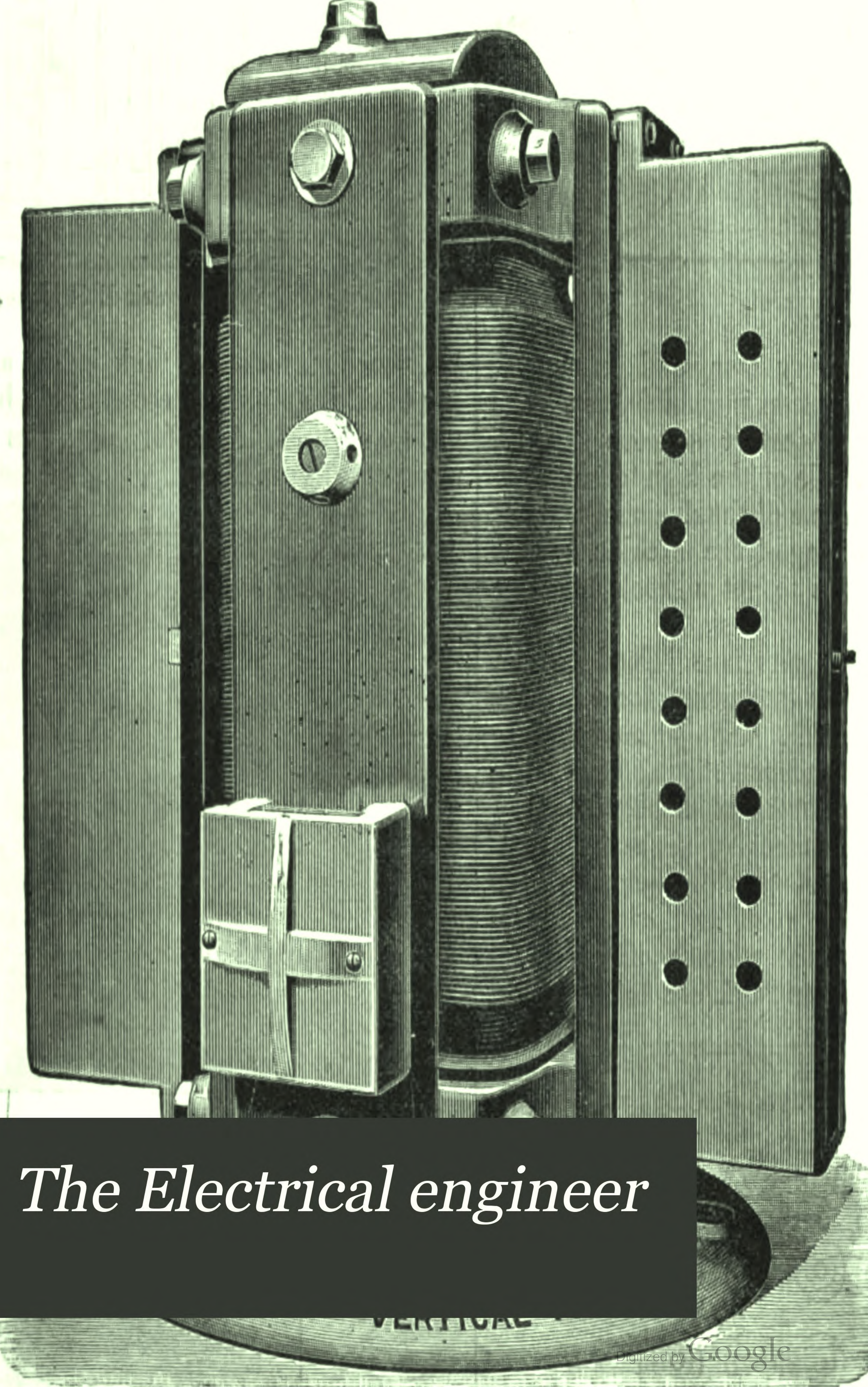

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THE

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NOTES.

Gassner's Cells.—The Gassner dry cells are being adopted for automatic electric boxes.

New Year's Honours.—Sir Frederick Bramwell has been raised by the Queen to the baronetage.

Industrial Education.—A book by Sir Philip Magnus on "Industrial Education" has just been published.

West Brompton.—The central station of the House-to-House Company at West Brompton is now open.

Telegraph Convention.—The Argentine Republic has just joined the International Telegraph Convention.

Fire at Derby.—On Saturday Messrs Rowbottom and Goodwin, electrical engineers, Derby, were partially burnt out to the extent of £300.

Southwark Subway.—It is stated that the electric motors to be supplied by Siemens Bros. on the Southwark Subway will be of 100 h.p. each.

The Institution of Electrical Engineers.—The first meeting of this institution will be held on the 10th inst. The president, Sir William Thomson, will deliver his inaugural address.

Vienna.—The central station for Vienna, which is being constructed by Messrs. Siemens and Halske, is rapidly approaching completion, and is expected to be ready for work almost immediately.

Mordey Alternator for Sheffield.—Messrs. Tasker's central station at Shefield, which is running with Thomson-Houston arc plant, has now been fitted with a 35,000 watt Mordey alternator for incandescent lighting.

Paris Exposition.—The railway at the Paris Exposition will run from end to end, and will consist of 100 carriages of various types, driven by 15 engines worked variously by steam, compressed air, and electricity.

Brussels.—The formation of a syndicate is announced, consisting of Messrs. Mourlon Frères, E. Gerard, Van Rysselberghe, La Société Electrique, etc., for the establishment of a central light and power station for Brussels.

New Words.—Mr. A. R. Bennett, in the *Telephone*, suggests the word "telephrase" for a telegraphic message. The counsel for the Dolbear telephone, in the United States, has suggested the word "amberism" for static electricity.

Long Distance Telephones.—Two new telephone lines have been run in Switzerland—one from Langenthal to Aaran, and the other from Neuchatel to Berne. A line will shortly be established between Frankfort-on-Main to Hanau.

Koenigsberg.—The town of Koenigsberg, in Germany, is to have a central lighting station, owned and carried on by the municipality. The cost is estimated at a million and a half francs, and it is hoped to commence running in the spring.

Book Received.—We have received a copy of the new book on "The Telepone," by William Henry Preece, F.R.S., and Julius Mayer, Ph.D. (Specialists' series), published this week by Whittaker and Co., 2, White Hart-street, Paternoster-square.

Election Dodges.—According to a paragraph in the *Pall Mall Gazette*, Sir John Pender, in an interview at Glasgow, said that if he were returned he could bring work to the Clyde connected with submarine telegraphy. Is this bribery and corruption ?

Speed of Telegraphing.—To cope with the increase of business between London and Aberdeen and other towns, an improved system has been introduced, which allow the speed of telegraphing to be increased from 300 to 350 words per minute.

Berlin Exhibition.—An exhibition is to be held in Berlin in April and June this year, consisting of every kind of life-saving and accident-preventing apparatus. The arrangements are now fairly complete, and will include some electrical apparatus.

The Woodward Battery.—The Woodward Electrical Company sold last month 16,348 cells of the Detroit storage battery to a traction company—84 cells to be used for each car. The order amounts to 100,000dols. Another very heavy order has also been given.

Tenders for Chelmsford.—Tenders are invited for lighting the town of Chelmsford by (*a*) gas and oil, (*b*) electricity, for a period of one, two, or three years. Tenders by noon, January 17th. Particulars of Mr. Chas. Pertwee, borough engineer, Chelmsford.

The "Times" by Electricity.—Mr. Albert Gray, of New York, says they can now send out 2,000 h.p. from their motor station in that city. If the London *Times* would give them the contract, he would undertake to run their presses by electrical power from New York.

Piccadilly Electric Railway.—A meeting was held on Wednesday at the offices of the Prudential Assurance Company, in which a resolution was carried objecting to the proposed electric railway between Holborn and Piccadilly, and a committee was formed to oppose the scheme.

Composite Containing Cell.—A new material is introduced by the Composite Cell Company, of 35, Broadway, New York, for storage and battery cells. It is used by the Julien and other companies; it is made up of various materials, including asbestos, and is tough, durable, and impervious to acids.

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Spain.—The town of Valencia is to have a central station for 20,000 lamps, due to the initiation of the Marquis de Campo. The installation will be carried out by Sen. Planas y Flaquer, of Gerone, and will cost an outlay of a couple of million francs. The power will be taken from the River Turia.

New Transatlantic Cable.—It is rumoured that a contract was signed last week between the Government and the International Cable Company, which has its head-quarters at Brussels, for a new Transatlantic cable to be laid to Bermuda and Halifax by way of Portugal and the Azores. We do not believe in such rumours.

Electrolysis of Tumors.—M. Darin, of the Henry Giffard Hospital, Paris, has cured nine cases by electrolysis of cancer, tumor, hydrocele, etc., besides many cases of depilatation, or destruction of hair follicules. These results were obtained with extremely simple apparatus, very easily manipulated, with the use of the Gaiffe chloride of zinc battery.

Madrid.—The Government regulation as to the sudden lighting of all theatres so far does not seem to have resulted in success in all cases. The light in many of the theatres is deficient—probably on the score of economy of outlay—giving a poor light, and breakdowns are not unknown. Last week the popular Zarzuela Theatre began to get dimmer and dimmer, and the audience streamed out, demanding back their money.

A Woodhouse and Rawson Station.—Among the multiplicity of central stations which are being established or proposed in all directions, we hear a whisper that Messrs. Woodhouse and Rawson, Limited, are not to be left in the cold, and are intending to establish a central station of their own. It is a sign of the times that good profit is to be made when well-established businesses are taking up the central station work themselves.

The Julien Cars.—On the Fourth-avenue, New York, the Julien cars now make a run of 36 miles with one charge. The round trip of 12 miles consumes 15 electrical h.p. hours. The cost is 1d. per h.p. hour; this is 1s. 3d. for the trip, 1¼d. per car mile. At 75 miles a day this would be 7s. 10d. per day. These data are taken from the books at the Julien Company's station, and attention is being given to obtain even still greater economy.

As Here.—Ruinous competition in the States has resulted, in many cases, in companies continually taking contracts at prices leaving no profit. An electric trust has been mooted for some time, with no practical effect, so far; but it seems probable a chamber of control may be formed to fix minimum per lamp prices for arc and incandescent plants, and to prevent several companies attempting to exploit towns where a central station is already successfully established.

The Stettic-Telephone.—Mr. James Lowth, of Chicago, according to the New York *Electrical Review*, has perfected a telephone on a new principle. He has been at work on the instrument for some years. It combines transmitter and receiver, and the transmission is obtained, not by vibration of the sounds from the mouth, but by the vibrations of the throat, against which the lower part of the transmitter presses. It is stated that the instrument has worked clearly over a line of 75 miles.

Barnet.—On Boxing Night Mr. Joel started his permanent engine and dynamo at Barnet, and all seems to be going successfully. The people of Barnet have now settled down to satisfaction with a good average light instead of the blaze they expected; and at the Local Board, at the last meeting, on Tuesday, the result of the discussion was that the cheque for last quarter was passed and paid, and satisfaction with the lighting was expressed by the Board. So ends the preliminary fight. Extension has now to begin.

Society of Arts.—On Wednesday, the 23rd inst., a paper will be read at the Society of Arts, by Prof. George Forbes, on "Electric Meters for Central Stations." Papers, for which dates have not yet been fixed, will also be read on the "Manufacture of Aluminium," by Mr. William Anderson; on "Secondary Batteries," by Mr. Preece; on "Automatic Selling Machines," by Mr. J. G. Lorrain; on "Arc Lamps and their Mechanism," by Prof. Sylvanus Thompson; and on the "Use of Spirit as an Agent in Prime Movers," by Mr. A. F. Yarrow.

The Way to Do It.—In the States it is a common occurrence for orders to be received and executed for a central station to be running within a fortnight after receipt of order. What would be thought in England if we announced one week that some town—say Warwick—had ordered a public central lighting plant, and that in the next week's issue we gave full description of the successful start of the station? We need not attempt to be quite so quick as this, but where is the need for all the usual delay and deliberation on the part of our town and municipal authorities?

New Telephonic Journal.—The first number of *The Telephone*, for Jan. 1, 1889, has reached us—a well-printed paper of twenty-four pages, illustrated with numerous small cuts. It contains a round dozen of articles long and short on telephony, besides one or two translations and notes upon general electrical work, and statistics and quotations of telephone companies. It is to be issued fortnightly, price 6d.; publishers, Messrs. W. Clowes and Sons, Charing-cross. We have no doubt that those specially interested in this branch of electrical work will subscribe with satisfaction to the new journal.

Paris Lighting.—At the last meeting of the Municipal Council of Paris the proposals presented by the third commission were adopted with reference to the concessions applied for by the six following companies: Edison, Geraldy-Deprez, Gaston Sencier, Société du Secteur, Compagnie Victor Popp, and La Parisienne Electrique. The council also accepted the resolutions of the commission appointed to settle the contracts for machinery and plant, and accepted the tenders of Belleville et Cie, Weyher et Omhemond, Lecouteux et Garnier, Compagnie Continentale Edison, and M. Patin.

Reunion at Glasgow.—On Friday evening, 28th December, the friends and workmen of Messrs. McWhirter, Ferguson, and Co., Faraday Electrical Works, Glasgow, held their annual reunion in the hall, St. James'-street, when over 50 sat down to a sumptuous repast. The chair was occupied by Mr. Wm. McWhirter. After tea the chairman addressed the meeting on the progress made by the Faraday Electrical Works during the last five years, and especially impressed upon the apprentices the need for constant and diligent study to enable them to command respect in their chosen profession as electrical engineers.

Fishing by Electric Light.—The French fishermen on the coast of Maine now use a small primary battery, with an incandescent lamp, to attract the fish, the whole

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being dropped overboard and regained when the trip is ended. The old method of leading wires from a source of electricity on board to the lamp often resulted in fouling the nets. The battery consists of six Bunsen cells, in which, however, chromic acid is placed instead of nitric acid, formerly used. The cells are connected in tension with a 12-volt Edison lamp. We shall no doubt soon see a very general adoption of this method of fishing by coast fishermen.

Not the Institute.—We note that the last issue of the *Journal* of the Society bears the new name as adopted in last general meeting as a supplementary title. Attention should be called to the fact that this new title is not the "Institute" of Electrical Engineers; this was a mistake which was easy to fall into at first, and many obtained the idea that such was the new title. This mistake is embodied in an otherwise pretty fancy of a monthly contemporary illustrating the apotheosis of the society. It should be well enough known now, since the publication of the resolutions, that the new title is, "The Institution of Electrical Engineers."

Electric Thermometer.—M. Chaperon has recently devised a galvanic couple sensitive to light for measuring degrees of illumination. A somewhat similar application to measurement of temperatures has been devised by Mr. Bruce Warren, chemist to the India Rubber Company, Silvertown, who has discovered that arachide oil varies in resistance very rapidly with change of temperature. The oil is placed in a test tube in which two wires from a galvanometer are immersed. The combination then acts as a thermometer, and is sensitive enough to indicate minute fractions of a degree. The discovery may possibly have an important practical application.

The Fortin Cell.—The French technical press describe a new battery devised by M. Fortin. It is constructed of rectangular cells, 4in. square by ¾in. deep, placed one above the other. Three small carbon rods project through holes in each cell slightly above the surface. The zinc plate rests on these, and the positive plate of hard carbon rests upon three plugs of indiarubber placed on the zinc plate. M. Fortin states that this battery will run a 10 c.p. lamp for 10 hours at the cost of a few centimes. The solution is made by dissolving 1lb. of bichromate of sodium in one gallon of water, to which 1lb. of commercial sulphuric acid has previously been added.

Lens Globes for Electric Lamps.—Mr. S. Heimann, of New York, has designed globes for arc and incandescent lamps, consisting of a combination of lenses so arranged as to compensate for the irregular radiation of light in different directions and angles from the lamp. These consist for arc lamps of two lenses of a globe made in the form of a cylindrical double convex lens round the side of the globes, by thickening the glass opposite the arc; and in the incandescent of a thickening of the bulb at the sides and bottom so as to render the light stronger in those directions that it is naturally weakest. The idea may be capable of a practical application, and is at least worth consideration.

Light and Power Station in Austria.—An interesting installation for the distribution of light and power has been constructed by Messrs. Siemens and Halske in Weissembach, Austria. A number of houses are lighted, including villas, hotels, restaurants, and two mills, and at the same time power is transmitted from one of the mills to the other, a distance of a quarter of a mile away, using part of the power of a neighbouring waterfall. A Jonval turbine furnishes 20 h.p., which, by means of a countershaft, drives a Siemens dynamo, giving 130 volts and 90 amperes. A cable is run to a motor at the further mill, and leads are run off made along the circuit for the lamps, which are lighted only at night, when the motor is not working.

Price for Motor Service.—The charge for electric motors in New York is ½d. an hour for a sewing machine, 16s. 8d. a week for 1 h.p., 25s. for 2 h.p., and 12s. 6d. a week extra for each additional horse-power. The prices are not absolute, but vary somewhat with certain conditions. The cost generally is less than that of steam; the great advantage is that no great amount of capital is invested, as is the case with steam or gas engine plant. The exact amount of power used is charged for, and it can be turned off as easily as gas or water. A 1 h.p. motor will run three Gordon presses and a cylinder press. An eighth of an horse-power motor drives a fan or sewing machine. The cost of running an ordinary passenger elevator by electrical power is about 33s. a week.

Important Decision of the Board of Trade.—The Board of Trade, by virtue of the powers vested in it by the Electric Lighting Act of 1882, has, we are informed, decided to refuse the whole of the applications that have been made to it to grant licenses for the supply of the electric light to any part of the metropolis. The effect of this decision is that all applications for supplying the electric light to any part of the metropolis will have to be sought by means of provisional orders, which, if granted by the Board of Trade, will have to receive the sanction of Parliament before they can become operative. All provisional orders that may be granted will, therefore, be embodied in a confirmation Bill and referred to a Select Committee, before whom opponents will be heard.—*Daily Papers.*

The Telephone in London.—The messages transmitted along the United Companies' wires on the 17th ult. amounted to 103,428, the highest yet reached for any one day; while the messages for the week ending 18th ult. amounted to summed up 586,294, being at the rate of 30 millions of messages per annum. The United are erecting a main trunk route to the North, and have already built half the trunk that is required to connect London with Birmingham. A main trunk to the West is also being surveyed, and way-leaved with a view of placing Bristol and the South Wales coal-fields in telephonic communication with the metropolis; while a new route to the South is in progress for the benefit of Brighton and the towns on the Southern Coast. As these routes are gradually constructed outlying towns can be joined up to them, and thus establish a complete network of telephonic wires between the provincial towns and London.

Photographic Arc Lamps.—We give elsewhere illustrations of arc lamps adapted for photographers' uses, by Faraday and Son. It will obviously be easy, where central stations are active, for photographers to obtain current for these arcs from the mains. In isolated circumstances this is not possible, and no good battery or generator is at present practically available. Two methods suggest themselves: a small generator, such as an oil or petroleum engine—the Shipman oil engine, Serpollet's instantaneous steam generator (recently described), or a small compact water or gas engine—rotary or other. But possibly some of our inventive geniuses will produce an exaggerated Ruhmkorff coil to commute heavy currents from—say, two large storage cells at heavy

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discharge for the period of two or three minutes into alternate currents, and transform them up to 40 or 50 volts, and so produce a temporary arc light. This would be exceedingly convenient in many cases for arc lamps, and would save excessive cost for batteries for the necessary voltage.

Albion T. Snell on Electromotors.—The next meeting of the City Guilds Old Students' Association will be held at the Central Institution, Exhibition-road, South Kensington, on Wednesday, January 16, at 7.45 p.m., when what we are sure will be a most interesting paper by Mr. Albion T. Snell (of Messrs. Immisch and Co.), upon "The Design of Electromotors," will be read. The outline of Mr. Albion T. Snell's paper is as follows: The dynamo as a reversible machine; the methods of designing motors; the torque; the armature considered as an independent magnet; the field-magnets; relative power of armature and field-magnets; shape of magnets practically immaterial to the general result, providing sufficient excitation be given; pole-pieces; predetermination of characteristics—insufficiency of present methods; method of examining distribution of magnetic field in dynamos and motors; method of estimating quantitatively the heat waste and frictional losses in a motor by brake tests. The exceptional interest of the paper to electrical engineers will, no doubt, cause a good attendance of visitors, besides a full meeting of members.

Overhead Wires at Birmingham.—The *Birmingham Daily Post* has carefully discussed with an eminent electrician the question of overhead wires, and gives its adherence to the tentative policy of overhead pioneer wires under proper restrictions. After reviewing the reasons for such a policy—the difficulty of laying underground mains, of obtaining consent of the authorities, of judging the demand at various points, and of settling upon the size of main cables for maximum supply—the *Post* concludes as follows: These arguments, so far as they suppport the desirability of allowing a temporary use of overhead wires, seem to be well grounded. Of course all that is said about inconvenience to the electric lighting companies would go for nothing if the danger from overhead wire were as grave and pressing as the alarmists make out; but the evidence does not satisfy us that it is. On the contrary, the risk seems to have been exaggerated, and the public may therefore await with comparative equanimity the probable decision of the committee in favour of the use of overhead wire for purely pioneer and experimental purposes.

Internal Friction of Engines.—Professor Thurston, at the Scranton meeting of the American Society of Engineers, investigated in detail the loss in friction internally in the various parts of steam-engines. The friction of the main shaft is one-half or one-third of the whole loss, and the introduction of a system of oil baths would tend to regain most of this loss. The next item is that of the piston and rod, which varies, and might be considerably reduced. The third item is the loss in friction of the valve in engines having unbalanced valves. In the straight line engine the loss has been brought down from 26 to 2·5 per cent. by skilful balancing of the valve. From the thermo-dynamic point of view the steam-engine is nearly perfect. An ideal engine would consume 10lb. of steam per h.p. hour, and engines have been made to work as low a consumption as 14lb. of steam. It is not impossible, if the internal losses by friction were carefully overcome, that the consumption in a good engine might be reduced to 12lb. of steam per h.p. hour, and most engines could be made to yield 5 or 10 per cent. of energy usefully, now wastefully consumed. Attention to the matters thus pointed out are well worthy the careful consideration of electrical engineers engaged in both private and central station work.

Electrical Action of Dental Fillings.—Dr. George W. Whitefield contributes to the *Western Electrician* an exhaustive and interesting article upon the galvanic action of dissimilar metals used as fillings in hollow teeth. He points out that Dr. J. V. Black has proved that unclean teeth are peopled with microbes (especially in between the teeth), which live on the *debris* left around the teeth; some of these exude lactic acid, which tends to destroy the teeth and gums. Dissimilar metals, Dr. Whitefield argues, when placed in different positions in the mouth set up electrolytic action. Gold is often used in one place and tin, or often a combination of mercury with tin, silver, zinc, and copper in amalgams, in other teeth. These, with the fluids of the mouth as excitants, give small currents of electricity, which often tend to eat away and roughen the surface of the teeth, giving lodgment to Dr. Black's microbes. With gold and tin fillings only, the baser metal becomes coated, and the action practically ceases, but with the amalgams the mercury allows the action to continue. If amalgam must be used, he concludes, use those grades which will readily become coated, as this reduces the galvanic action and protects the plug from the fluids of the mouth. Metallic fillings should be avoided for those teeth which are soft in structure, as the normal plasma exuded from the tubuli will tend to set up electrolytic action. Cement is the only filling that should be used in such cases, and in the course of 18 months or so the tooth will harden and be capable of proper manipulation, to prepare it for the king of fillings—gold. A tooth treated this way will not be sensitive, and the fillings will last.

Edison-Swan Catalogue.—The Edison and Swan United Electric Light Company have forwarded to us their catalogue of incandescent lamps for January, 1889. It is very complete, neatly got up, and arranged for ready reference in paragraphs. Particulars are given of the usual lamps at 48 to 110 volts; special miniature lamps 1 to 5 c.p., and larger lamps at 25, 32, 50, 100, 200, 500, and 1,000 c.p., the last three being for use on incandescent circuits in place of arc lamps, a branch rapidly becoming of greater importance. The Edison and Swan Company are now giving considerable attention to these high-power lamps. With regard to efficiency, all lamps marked at less than ·9 ampere are marked at 4 watts per candle, and above this at 3·5 watts per candle, though special buyers can mark their own efficiencies. The company now make the bulbs of their lamps in two shapes—round and pear-shaped, and these are made in six standard sizes in all. Lamps are made for the following terminal fittings: Bottom loop brass collars, black glass ends, side contacts, central contacts, Edison screws, brass or copper lugs. These various terminals are illustrated, as are also the different shapes of bulbs and the bayonet-joint and side-lug lampholders. Various regulations as to packing, delivery, mounting, lamps obscured, silvered, and varnished in colours and other matters of interest to buyers of lamps are fully given. One point of interest is the detail given of the standard cells employed by the company as devised by Dr. Fleming. The company are prepared to furnish standards of resistance, or legal ohms, and also standard

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cells for use in calibrating galvanometers. All previous lists are cancelled by this catalogue, which should be on the desks of all electrical engineers.

Grosvenor-place to be Lighted.—At the last meeting of the St. George's Vestry, the lighting of Grosvenor-place publicly with electric light was decided upon. The Electric Lighting Committee recommended that an application from the London Electric Supply Corporation, Limited, to light the area between Hamilton-place and St. George's Hospital, as far down Grosvenor-place as Halkin-street, be granted upon an agreement being entered into embodying the following conditions—viz.: That the corporation bear the whole expense of the laying of wires, etc., for making the experiment, and that a light quite as good as that now given by gas be supplied to the satisfaction of the Vestry, who will pay £300 per annum for the lighting of the area, the agreement to be for a period of twelve months certain, and to continue unless determined by three months' notice on either side; that the corporation reinstate the parish lamps and paving, if removed or interfered with, to their present condition, and that no use of the parish lamps by the corporation shall in any way interfere with their being lighted by gas at any time, if so required; and the details as to the exact system of lighting be left to the corporation. The Electric Lighting Committee recommended "That the Vestry resolve that it is in their opinion to the advantage of this parish, and, so far as the Vestry could see, of the inhabitants of London generally, that joint-stock companies should commence operations for electric lighting under licenses rather than provisional orders." Lord Hobhouse, in moving the adoption of this report, said the company had already wires laid within this area. The expense of lighting the area by gas was about £300, and so they had fixed that sum in the agreement. Mr. Southon seconded the motion, which was agreed to, with a rider prepared by Sir Walter Phillimore, regretting that the Board of Trade had refused to enter into the proposal of granting licenses on a principle which would seem to prevent any licenses in future being granted to them.

The Electric Lighting Act.—In the House of Commons on the 20th ult., in answer to questions by Mr. Watt, the President of the Board of Trade (Sir M. Hicks-Beach) said the Electric Lighting Act, 1882, did not preclude the granting of licenses to one or more persons, firms, or companies to light the same area; that the Board of Trade could not give power to break up streets except under a license or provisional order, and that enquiries as to the ability of undertakers to carry out the work before licenses were granted were made by the Board of Trade. Two licenses have been granted since the last report to Parliament. In reply to the question as to whether the reason of the abandonment of the licenses obtained by companies under the Act of 1882 was the enormous law costs incurred by the opposition of the Local Boards, Sir M. Hicks-Beach said that no such reason as that referred to by the hon. member had, to his knowledge, been assigned for the abandonment of licenses. Mr. Rowntree asked the President of the Board of Trade whether his attention had been called to notices given for supplying electric light in the parish of Kensington, under the Electric Lighting Acts, 1882 and 1888, by the four following companies—viz., the Kensington and Knightsbridge Electric Company, Limited, the Chelsea Electricity Supply Company, Limited, the Notting Hill Electric Lighting Company, Limited, and the House-to-House Electric Supply Company, Limited; whether he was aware that the said companies proposed to conduct their operations mainly, or very largely, within the same area, and in many instances to take power to break up the same streets, roads, or places; whether it was the duty of the Board of Trade, before making any provisional order, to take cognisance, of its own motion, of such *prima facie* objections; and whether the Board would not take any cognisance unless and until it was moved thereto by the local authority, or other parties interested. Sir M. Hicks-Beach: The answer to the first three questions of the hon. member is "Yes"; and the answer to the last is, that it is the duty and practice of the Board of Trade, in framing a provisional order, to consider any objections to which their attention is called, and also any such as may occur to them.

Electric Tramways for Milan.—A commission was recently appointed by the Omnibus Company of Milan to visit and report upon various systems of electric tramways in use in Europe. This commission consisted of Signore Pompeo Moneta, C. Margutly, and B. Cabella, who were requested to give special attention to accumulator systems. The commission, after having examined the principal English and Belgian lines, regretted they had not been able to ascertain that any of the systems worked with storage batteries were at present successful from the financial point of view. At Brussels the Julien system gave satisfaction in working, but was costing 4 centimes per car mile in excess of horse cars; the commission, however, remarked that it was impossible to judge fairly of the expense with a total of only four or five cars running. The gradients also were heavy, varying from 3 to 12 per cent., where the electric cars were in use. The Elieson cars were not running on the Stratford line when the commission visited London, but they had, nevertheless, considered the system. The commission were not in favour of the use of electric locomotives. They had examined all the various accumulators proposed, but the cells of the E.P.S. Company and of Reckenzaun were the only ones that the makers would guarantee a maximum expense of maintenance. Among the systems of gearing, that of Reckenzaun seemed the best worked out and most practical. Signor Moneta recommended particularly the employment of two motors to each car; he considered it advantageous to transmit the power to both axles instead of to only one. He also praised the system of Mr. Reckenzaun, by which the speed or power of the motor could be varied, at the same time saving current from the batteries. This is done by varying the resistance of the coils of the motor by connecting up in different combinations. The report terminates with the consideration of the cost of running with electric traction as applied to the line from Milan to Monza, with eight large cars, carrying 50 passengers. This line, at present run by horses, has a length of 16 kilometres (nearly 10 miles), and although there are no heavy gradients it is impossible to run to the regulation time, which, including stoppages, is fixed at 58 minutes. Signor Moneta calculated the cost of electric traction for the line to be 25 centimes (2½d.) per car mile, inclusive of coal, oil, waste, salaries, etc., depreciation at 12½ per cent. for machinery, and of 30 per cent. for accumulators, and allowing interest on capital at 6½ per cent. The conclusions of this report, says the *Bulletin Internationale de l'Electricité*, from whom we abstract the above, are very favourable to the adoption of electric traction at the line from Milan to Monza, and are of great interest, being, as they are, the result of serious and impartial examination of the principal storage systems proposed in Europe.

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LITERATURE.

Dynamo Electric Machinery. By SILVANUS P. THOMPSON, D.Sc., B.A. (Third Edition.) E. and F. N. Spon: London, 1888.

That Prof. Thompson's "Dynamo Electric Machinery" satisfies more or less completely the wants of a somewhat numerous class of readers is shown by the fact that the work has now reached a third edition. In the volume before us a very successful attempt has been made to write the subject up to date, and, considered as a manual for students, there is not perhaps much fault to be found with the book. But between the practical considerations which guide the work of dynamo making as carried on in the factory and the traditions which govern the study in technical colleges there is, apparently, a great gulf fixed—a gulf, moreover, which Prof. Thompson's book has not yet bridged.

In his preface to the third edition, the author remarks that the mathematical portions which appeared in former editions have been curtailed, a fact which is to be regarded as a healthy sign. The men who design dynamos contrive to do with as little mathematics as possible, and, generally speaking, have neither the time nor the inclination to soar in analytical flights. They regard mathematics strictly in the light of a means to an end, and are somewhat prone to look with contempt upon the yards of symbols which it has been the fashion to write in connection with dynamo investigations. The formulæ of the practical man are few and simple, but in his hands they form powerful mental tools which are capable of turning out a vast amount of useful work.

The first chapter of this book is occupied with introductory matter, historical notes, and definitions of electric and magnetic units. The author starts the very first paragraph by defining the dynamo as "a machine for converting energy in the form of mechanical power into energy in the form of electric currents, or, *vice versâ*, by the operation of setting conductors to rotate in a magnetic field, or by varying a magnetic field in the presence of conductors." This definition is certainly comprehensive enough for its place at the beginning of the work. We should have thought that moved to a position at page 35 it would have been more in harmony with a general plan of piecing the dynamo together bit by bit, which seems to be foreshadowed in Chapter II. We cannot say that we agree with the order in which the matter of the book is presented. It seems to us that the abundance of material suffers through absence of system, and that the edition now before us is impaired by the author clinging too closely to the plan of former ones.

After dealing with the Organs of Dynamos, the author considers, in Chapter IV., the Induction of Currents in Armatures and the Distribution of Potentials around the Collector. Prof. Thompson tells us here that in every well designed machine the induction in the sections of the armature can be represented by a curve of sines. This is, we think, an error. As a matter of fact, every designer aims at preventing his induction curve from being a curve of sines, because he well knows that with such a state of things he will have on his collector a neutral *point* instead of the neutral *surface* which he wishes. In all good dynamos there is a number of the armature-coils idle, and made purposely so, that sparking may be avoided. It is only in multipolar disc machines, where the poles are close together, that there is difficulty in getting a neutral surface or any considerable length of armature core through which the lines of force run without diminishing in number. But in all machines the main thing is to avoid injurious sparking, and this condition becomes very difficult of attainment when a curve of sines represents the induction. *En passant*, we are unable to discover the value of Isenbeck's experiments as far as modern dynamo design is concerned. Nor can we find anything in present day machines to correspond with the archæological appliances sketched in Figs. 42 and 53.

In Chapter V., the reactions in the armature and magnetic field are dealt with, and at page 91 some extraordinary figures are given. The fact of Strömberg obtaining a greater demagnetising *effect* due to the armature as the field-magnet excitement was increased, is quite inexplicable. We do not see that such an effect could be produced by the field-magnets being of inferior quality or section, as the professor suggests. In such a case we might naturally suppose that the effect produced by a given armature current would be the same whether the magnet excitement were greater or less, but we are by such a supposition left as far as ever from a reason for the demagnetising effect increasing with an increased excitement. The language here is most ambiguous. "With 13,400 ampere-turns," the passage reads, "the demagnetising effect of 60 amperes in the armature was equivalent to 4,400 ampere-turns. With 25,200 ampere-turns the demagnetising effect of only 30·5 amperes was equivalent to 3,100 ampere-turns." What were the conditions of lead to the brushes? The author does not know. Does the passage mean that the field-magnet excitements required to produce given E.M.F.'s on open circuit have to be increased by 4,400 and 3,100 ampere-turns respectively when currents of 60 amperes and 30·5 amperes flowed through the armature? We are not told. But if this is the true meaning, the facts do not prove that "with stronger constant excitation of the field-magnets the demagnetising effect of the armature currents was greater." We cannot say whether it was greater or less until we see the saturation curve of the machine, for effect stated in ampere-turns and demagnetising effect are certainly not the same thing. The reader is left to guess at the meaning as best he may, and we may fitly ask, Why publish these apparently anomalous results obtained under conditions unknown? Is the students' perplexity likely to be lessened by their contemplation? Or if the author is unable to explain the facts, does he imagine that a tyro, plodding through his book for the first time, is likely to unravel them?

Chapter VI. deals with the different methods of governing dynamos, while in Chapters VII.—XIII. are described all the best known continuous and alternating-current machines.

Chapter XIV. deals with the principles of magnetism, leading up to the idea of the magnetic circuit, and giving, finally, a very complete series of sketches showing the various forms of field-magnets employed in practice. There is given on page 304 a formidable array of empirical formulæ, which have been invented at various times to fit the dynamo. These empirical formulæ may be ornamental, but they are all uniformly useless. It seems to us somewhat absurd that time and tissue should be wasted in fabricating such formulæ when we have the actual curves, as on page 300, from which can be measured directly the function of the induction which gives the ampere-turns required per centimetre length. The writer later on, at page 319, adopts the formulæ of the Brothers Hopkinson, and shows how they construct the characteristic from a knowledge of the dimensions of the machine. It may be observed here that though the advantage, pointed out by the author, of round over square bars for magnets is well known, we see round bars less frequently than rectangular ones. The reason is that when round bars are employed there must always be separate pole-pieces, and that rectangular bars lend themselves most readily to the designs most frequently seen. As a matter of fact, the design must be considered in its totality, and though the magnet-coils cost more with rectangular bars, there may be on the whole an actual saving in the machine over one having round bars and cast pole-pieces.

In Chapter XV. is developed the elementary theory of the dynamo, and in Chapters XVI.—XX. are given the characteristics of magneto, series, and shunt machines. The author is very far from clear regarding the reactions of the armature on the magnets. In a vague sort of way he states that there is a weakening of the field due to the current in the armature, but as many electricians, let alone students, fail to understand the exact nature of this reaction, there ought to be no ambiguity concerning it. The magnetic circuits should be drawn, and it should be clearly shown that the windings of the armature act on the circuits in the reverse direction to the magnetising coils when there is a lead given to the brushes. Though we observe that in several places the author deals with the phenomenon of

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self-induction, we do not see that he gives any hint as to the magnitude of the effect produced by self-induction in armatures of various kinds. This is surely an unfortunate omission, as the weakening effects before referred to, combined with the effect of self-induction, are so great as to render valueless the equations for compound-winding given later on. In ordinary sized machines compounded for constant potential, the series ampere-turns required on the field-magnets are from 50 to 100 per cent. greater than the formulæ give, while in large machines the weakening effect becomes enormously important, and the turns required may be 200 per cent. greater than indicated.

We are rather at a loss to discover the professor's drift in Chapter XIX. Having in a former place reduced the formulæ connecting the magnetising force with the induction to the simple form used by the Hopkinsons, he proceeds in the chapter under notice to develop a formula embodying an approximate law of the electromagnet discussed in a former chapter. The reader will very naturally enquire why the author doubles in this fashion, but we frankly confess our inability to satisfy his curiosity. The values given in Hopkinsons' curve are absolutely correct, that is admitted; the values given by the new formula are only approximate, that is conceded. The question is, why substitute with a view to accuracy something known to be untrue for something known to be correct, and why make assumptions in any shape or form when we can be guided by indisputable verity? We regard the "diacritical" number of ampere-turns as of no practical importance, nor can we find a single dynamo designer who takes any notice of it. It fitted very well into the formulæ which appeared in former editions of this work, but in our opinion it should now be relegated to the nirvana where the G, κ, H of other times, *et hoc genus omne*, find their everlasting repose. The last stage of inconsistency is reached when, farther on, the method of Hopkinson is employed to discover the values for coefficients to be inserted in the approximate formula.

It may be mentioned that, as a matter of fact, no equations for the curve of a series dynamo are required, and no one cares a straw about the shape of the curve at places other than those at which the machine is worked. What we have to do is to saturate the armature core to 18,000 or 20,000 C.G.S. lines, and pile up wire on the magnets to make the curve come down and ensure stability in the lamps. To do this, one finds the requisite magnetising force *à la* Hopkinson, and multiplies it simply by 2, a very easy operation, as will be admitted.

The method of treating alternating current dynamos adopted by the author might have been rendered clearer by a further use of graphic methods. Dividing modern alternating current machines into those with iron in their armature cores and those without, it may be said that no expression for the E.M.F. in the former can be given, because of the complicity of the reactions due to weakening effect and self-induction. At best the impressed E.M.F. required in order to produce a certain resultant E.M.F. has to be guessed at, and the relation of the former to the latter varies with each type of machine. On the other hand, the effect of self-induction and weakening in machines without iron is a small percentage, and, assuming that the resultant E.M.F. can be represented as a curve of sines, we can draw this curve, combine with it a curve of cosines to represent the E.M.F. due to self-induction, and build up from the two curves a third to represent the impressed E.M.F. We can then obtain from this third curve by measurement the strength of fields actually required for the impressed E.M.F. Chapter XXV. deals with transformers and motor-generators, the next seven chapters being devoted to the subject of motors. Much of the criticism previously made applies to this part of the work as well as to the part on dynamos, and we need not therefore deal with the chapters in detail. On the whole the matter is put pretty clearly before the reader, and the faults we have indicated can be easily remedied in future editions.

The student will find in this book a mine of information in which he may dig and be enriched, though he must not expect that with each exertion he will necessarily turn up a gem.

ELECTRIC LIGHT MEASUREMENTS.*

BY A. H. BATE AND E. GIMINGHAM.

With the rapid growth of electric lighting during the last seven or eight years there has arisen a demand for instruments measuring E.M.F. and current—and latterly for instruments measuring quantity of current—conveniently and with accuracy.

As far as ammeters and voltmeters are concerned, the problem may be said to be solved, at least for steady currents, but there is reason to believe that radical improvements will have to be made before we can give the public a thoroughly satisfactory coulombmeter.

With regard to ammeters and voltmeters, the problem has been a stiff one, because of the difficulties that are always met with in measuring very small forces accurately. Friction at pivots, torsion in suspensions, alterations due to temperature, and other small changes, are troublesome because their effect is not small compared with the feeble forces we are dealing with.

All electrical measuring instruments consume some power, and we can use this either as heat to stretch a wire or the magnetic effect to deflect a permanent magnet or soft iron needle, or we may use the dynamometer principle. There is only one practical voltmeter in which the current is used to produce heat—viz., Captain Cardew's, and, of course, Profs. Ayrton and Perry's modification.

Ammeters cannot be easily designed to work by heat. Prof. Forbes uses his convection current windmill for this purpose by hanging the moving part by a torsion wire and measuring the deflection. Several attempts—more or less successful—have been made to use this principle for ammeters. One inventor puts a thermometer in a coil and measures the rise of temperature when the current is passed, and another measures the bending of a strip made of two dissimilar metals. Mr. R. D. Smillie has patented an ammeter in which a strip of metal fixed at the ends is bent by being heated with the current in a way that strikingly resembles Profs. Ayrton and Perry's sag wire voltmeter The difference is that in this case the bending of the strip is measured instead of the true sag.

In volt and ampere meters which work on magnetic principles a choice has to be made between the dynamometer with small force and small errors and instruments in which soft iron or permanent magnets are used, and which, though their deflecting force is comparatively large, are subject to considerable inaccuracy.

Sir William Thomson has given us both ammeters and voltmeters controlled by gravity that are free from residual magnetism and almost all other errors. These instruments may be relied on as constant, and on varying standards with the same confidence that a foot rule may be. For laboratory standards nothing could be better than these dynamometer instruments. But for installation work we require an instrument which need not be accurate within about two per cent., but which must be easy to read. All dynamometer instruments have to be adjusted, either by moving a weight or bending a spring; and, although when making accurate observations it is as easy to turn a milled head, as it is to tap the case, an engine-room voltmeter must read directly, and should have large divisions.

To get large deflections and consume very little power is what we want, and the way to get this is to use soft iron. As a rule, instruments using soft iron give the same deflection as instruments without iron with one-third of the power. Such instruments as the Schuckert are well suited for engine-room work. The small piece of sheet iron which is sucked to the side of the coil retains very little residual magnetism

In the Schuckert voltmeter the divisions are only large at that part of the scale at which the instrument is intended to be used. Mr. Evershed has designed an instrument of the same type as the Schuckert, in which the field is modified by lumps of soft iron placed in the core; the object being to make the deflections equal throughout the scale. Although voltmeters of this type are liable to errors of, say, 2 or 3 per cent., we must remember that in the course of a few years lamps will probably be so much cheaper

* Paper read at the Students' Meeting of the Society of Telegraph Engineers and Electricians, December 6, 1888.

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that users will be careless about a few volts; and then, we may safely predict that rough and cheap voltmeters will be most used, and that instrument makers who have spent money and brains in perfecting instruments in which simplicity is sacrificed to accuracy will be but poorly remunerated.

It is in the laboratory that pains must be taken to get extreme accuracy. If absolutely true standards are available, the engineer can be confident that his 2 per cent. error is never more. For this reason we think the engineer should be able to send his instruments to a standardising laboratory occasionally, where they should be calibrated at a small charge; or, better still, that he should have portable standards of his own with which he can check the instruments in position.

Fleming and Gimingham's voltmeter is in every way suitable for such work. This dynamometer is made in a case about 4in. (cube), and the whole instrument only weighs 2¾lb. There is no reason why this instrument should not be as reliable as any dynamometer controlled by gravity, since a spring is considered by the best authorities to be absolutely constant.

It is very difficult to make an ammeter on the dynamometer principle which shall be convenient to use as a portable standard. The difficulty in all current-measuring dynamometers is to get large currents into the moving coils. Neither of the two methods which are used are suitable for portable instruments; the mercury for obvious reasons, and Sir William Thomson's ligament because it can only be bent through a very small angle, and therefore requires a long pointer to give sufficient indications. Perhaps the easiest way of measuring current with a dynamometer instrument is to pass the current through a low resistance—such as $\frac{1}{10}$th of an ohm—and measure the volts at the terminals with a low-reading dynamometer voltmeter.

Beside their accuracy, dynamometers have this great advantage over all instruments which contain iron—that they can be used for both alternate and continuous currents. No soft iron instrument will measure alternate currents correctly, unless it is specially calibrated for currents of the periodicty it is measuring.

For central station work, where the current has always the same period, soft iron may be used without inconvenience. It seems to be the rule in instruments designed to measure alternate currents to use a comparatively large mass of iron well laminated. Mr. Westinghouse uses a well laminated core of soft iron wires, which is sucked into a coil, in both ampere and voltmeters, for alternate currents.

A "potential indicator" for use at central stations, and designed on the same principle, is very interesting. Two coils, one of which carries current from a transformer on the mains, and the other volts reduced by a transformer, pull against one another on two soft iron cores hung from a balanced beam. A counterbalance weight is set on the beam so that it just balances the pull of the volt coil when normal volts are on, and when no current is passing through the mains. Thus, when a current is taken through the mains more volts have to be put on to keep the balance. In this way the fall of potential due to the current is allowed for. In looking up this subject we have come across several ingenious devices which, though they may be only curiosities, are worth mentioning.

In 1884 Miller patented a device which can be used as either a voltmeter or ammeter, made as follows: A piece of soft iron sucked into a coil is made to displace a liquid, and the amount of displacement is measured in a capillary tube.

An ammeter has been made consisting of a U-shaped tube placed between magnet poles containing mercury, which carries the current, and is more or less displaced by the current. Great attention has been paid to the errors due to the heating of a wire in a voltmeter, and some devices have been patented which are intended to compensate for temperature changes.

All these compensating arrangements, however, only compensate for outside changes of temperature, and the real trouble is with changes due to the coil being warmed by the current. By making a Cardew voltmeter case two-thirds of brass and one-third of iron, we can avoid all errors due to temperature changes which affect the whole instrument; but this does not diminish the error due to the wire warming the case. In a similar way the resistance of a voltmeter coil can be kept constant by making part of the conductor of carbon as long as the carbon and metallic parts of the conductor are at the same temperature. But when the current passes, the heat produced in the two parts of the coil depends on their specific resistances, and not on their temperature coefficients.

Seeing that there is likely to be a much larger demand for good coulombmeters than there ever has or will be for ampere and voltmeters, it is not surprising that great attention has been paid to this subject. It is only surprising that, as the result of so much work and so many patents, there are so few practical meters. *A perfect coulombmeter* measures the current as accurately when one lamp is put on as it does for 100 lamps. Its moving parts must be so few and simple that it cannot get out of order, and the force employed must not be so small as to necessitate carefully made pivots, which get damaged by damp and dirt.

The great difficulty which is found in designing a meter indicating by dials arises from the fact that the motion produced by the current must be proportional to the strength of the current.

We may make coulombmeters on one of three principles. If the magnetic effect is not used, we must employ either heat or chemical action. Of these, magnetic meters are necessarily most complicated, because when once the field has been set up the current does no more, and some arrangement of clockwork is required to register the strength of the field and how long it is maintained. In coulombmeters which work by heat or by chemical action the effect is continuous, and clockwork is not needed.

It is difficult to use the chemical action of the current because the whole of the current cannot be passed through the voltmeter, and shunting a part of it through is not allowable.

Mr. Swinburne has patented a voltameter meter, in which this difficulty is overcome by using the current to move an iron core. The motion of this core alters the resistance of the shunt circuit in which the voltmeter is placed. As early as 1882 Mr. Ferranti used an induction coil or transformer on the main house wire of an alternate current system, and measured the alternate current produced by a voltmeter arrangement. Prof. Forbes has designed two forms of meter in which the heat of the current is used. In the convection current windmill the reading is proportional to the current, because, though the heat varies as the current squared, the convection currents are proportional to the square root of the heat. In Prof. Forbes' other meter the heat of the current is made to evaporate water, which condenses, and is measured. The water condensed is a measure of the current. Mr. Edison in 1882, Prof. Blyth in 1885, and Weston in 1886, have patented meters depending on Faraday's disc dynamo principle. In these meters the current is led in and out of the rotating disc by mercury.

It is easy to see that Mr. Ferranti's meter is on the same principle, only his whole disc is made of mercury. A shallow round tray contains mercury, through which the current passes radially. This disc of mercury is placed between the poles of soft iron electromagnets wound with current coils, but having also a small volt coil to give sufficient initial magnetisation. A vane pivoted in the mercury takes the motion as the mercury rotates, and a simple chain of dials registers this motion. Dr. Aron's meter consists of a pendulum (actuated by clockwork) which swings a heavy piece of soft iron over a flat coil carrying the current This meter contains two clocks, one of which is controlled by gravity, and the other by the current. An ingenious arrangement registers the difference in the rate of these two clocks, and indicates it by dials.

Mr. Sprague has invented a most ingenious meter depending on the deposition of metal. Between two copper electrodes, from which the current is passed, there is a copper cylinder free to rotate in the liquid. The current passes through the cylinder (as the path of least resistance), depositing copper on one side and removing copper from

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the other side. In this way the centre of gravity is disturbed, and the cylinder slowly rotates.

A great number of meters have been designed which, however ingenious they may be, are either too complicated for practical use or are faulty in principle. The pull of a solenoid on a soft iron core has been made to govern clockwork by shortening the pendulum, or the hairspring of a clock, or to govern the flow of water through a valve. In one voltmeter meter, for alternate currents, the current is measured by weighing the copper disintegrated from the electrodes.

ELECTRIC LIGHTING IN LONDON.

The following, from the pen of Mr. R. Hammond, appeared in the *Times* of January 3 :

With reference to the statement in to-day's newspapers to the effect that the Board of Trade, in virtue of the powers vested in it by the Electric Lighting Acts, has decided to grant no licenses in the metropolitan area, I beg to call your attention to the following correspondence with the Board of Trade on the subject :

"Dec. 28, 1888.

"Sir,—I beg to hand you herewith a report of the proceedings at the general meeting of the London Electric Supply Corporation, Limited, and to draw your attention to a statement of the chairman therein contained that 'within the last fortnight the Board of Trade has decided not to grant licenses to anybody in the metropolis.'

"I should esteem it a favour if you would kindly inform us whether any action has been taken by the Board of Trade justifying this announcement.

"I am, sir, your obedient servant,

"ROBERT HAMMOND.

"H. G. Calcraft, Esq., C.B., Secretary to the Board of Trade, Whitehall-gardens, S.W."

"Board of Trade, Railway Department, London, S.W., Dec. 29, 1888.

"Electric Lighting Acts, 1882 and 1888.

"Sir,—I am directed by the Board of Trade to acknowledge the receipt of your letter of the 28th inst., inquiring whether any action has been taken by this department to justify the announcement that the Board of Trade has decided not to grant licenses to anybody in the metropolis.

"In reply, I am to state that the only decision at which the Board of Trade have arrived, with respect to applications for licenses in the metropolis, is that announced in the letters addressed by this department to the London Electric Supply Corporation, Limited, and the Metropolitan Electric Supply Company, Limited.

"From these it will be seen that the only decision that the Board of Trade has come to is not to grant licenses to companies for extensive and important areas in the metropolis. "I am, sir, your obedient servant,

"HENRY G. CALCRAFT.

"R. Hammond, Esq., House-to-House Electric Light Supply Company, Limited, 117, Bishopsgate-street Within, E.C."

From this announcement it will appear that the statement published in the Press is incorrect, and that the Board of Trade is actuated to-day by the same policy as that which it enunciated in its letter of the 17th of August, 1883—*i.e.*, that a license is the form of tenure under the Electric Lighting Act properly applicable to small areas, whereas large areas can only be properly dealt with by means of provisional orders.

The question, therefore, which the Board of Trade and the local authorities have now to decide is whether the time has arrived when, in the public interest, the metropolis shall be dealt with by the allotment of large areas to certain electric light companies under a 42 years' tenure, or whether it would not be a more prudent course, in the present state of the industry, to insist that those companies that are applying for this permanent form of privilege should, in lieu thereof, be granted licenses for a short number of years and for limited areas, in order that the merit of their pretensions may be tested by a probational period of working.

As one who has taken from the beginning an active part in the development of the industry of house-to-house lighting by electricity, I take this opportunity of stating some of the grounds upon which it may be advisable for the local authorities and the Board of Trade to grant licenses for limited periods and for limited areas in the metropolis in preference to provisional orders giving a 42 years' tenure :

1. No district lighting has up to the present time been carried out in the metropolis of so satisfactory a nature as to warrant the Board of Trade and the local authorities in proceeding at once to the apportionment of the metropolitan area by means of provisional orders, and no district lighting whatever has been carried out over an extended area by means of underground mains—the mode of distribution contemplated by the Act.

2. It would very prejudicial to the interests of the public to be served by electric light companies who were unable to thoroughly carry out the work, and until the new crop of electric light companies in the field have proved by natural selection which is the fittest, no 42 years' tenure in the metropolis should be granted at all.

3. It is urged by many that the electric lighting of the metropolis has been sufficiently long delayed, and that if it be still further delayed in order to discover which are the best supply companies, the interests of the consumers will suffer; but the fact is that the work carried out under licenses, say, within the first 12 months, will be quite as extensive as that which would be carried out in the same period under provisional orders.

4. Under the provisions of the Electric Lighting Acts the companies intending to apply for provisional orders have to give notice of their intention to do so prior to the 1st of July in each year, and it happens that only two companies had the temerity in June last to apply for the metropolis *en bloc*, and the immediate apportionment of the metropolitan area by means of provisional orders would practically lead to that area being handed over to these two companies, irrespective of whatever knowledge and experience may be available for the public at the hands of those companies which such an apportionment would exclude.

5. If in any form the electric lighting of the metropolis is to become the province of the new county council, it would be as well that until that body gets to work no action on the part of the Board of Trade or the local authorities should tie its hands by granting extended privileges to so limited a number of supply companies as that indicated above.

There are many other considerations of a technical nature which I refrain from touching upon, as I feel that I have already sufficiently trespassed upon your valuable space, but I may mention, in conclusion, that so little is apparently known in England as to the erection of central electric lighting stations that one of the two companies seeking for powers in the metropolis has actually given out the order for the erection of its first station to an American firm, though from a recent visit which I personally made to America I am disposed to agree with those English electrical engineers who believe that there is no reason why, with the splendid apparatus now being manufactured in England, first-class work cannot be done by English firms.

The strong plea that I set forth in this letter is that time should be given to prove which is the best supply company or companies in the field before giving permanent tenure to any.

"Journal" of the Society.—The last number of the *Journal* of the Society of Telegraph-Engineers, just issued, contain reports of the papers and discussions in the following subjects: "Ocean Temperatures in Relation to Submarine Cables," by William Lant Carpenter, with a sheet containing numerous illustrations and diagrams ; and on "A System of Electrical Distribution," by Henry Edmunds. The reply of Mr. Edmunds is not included.

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical-Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

PROSPECTIVE AND RETROSPECTIVE.

A HAPPY AND PROSPEROUS NEW YEAR.

There can be no better time than the beginning of a new year to take stock and think over the might have been. Æsop used to write or recount fables with a moral at the end. Parsons preach sermons and tag on the moral. The fond parent tells a doleful tale to his or her child about what happened to Budge or Dot through eating unripe fruit, with the inevitable moral, don't! Can't we have the moral without the preaching? What a lot of time would be saved in talking or writing, but no, it is the custom, and custom is a slave-driving operation that puts to shame all kinds of whips and scorpions. So then we have to find a moral, and, as accessory to this, to preach a sermon. What a nuisance books are that have no index, and what a nuisance indexes are that do not point out! We desired to give Mark Twain's version of "go to the ant thou sluggard, consider her ways and be wise," and after some trouble, his "Tramp Abroad" having no index, the following extract is found. But first to give a clue to the drift of the context of the part not extracted. The humourist describes a scientific investigation as to how far the life of the modern ant conforms to Solomon's ideal, part of which depicts an ant's action after finding what is evidently thought to be a grand prize. The finder does not get home with his booty, but "finally stops to rest, and a friend comes along. Evidently the friend remarks that a last year's grasshopper's leg is a very noble acquisition, and enquires where he got it. Evidently the proprietor does not remember exactly where he did get it, but thinks he got it around here somewhere. Evidently the friend contracts to help him freight it home. Then, with a judgment peculiarly antic (pun not intentional), they take hold of opposite ends of that grasshopper leg and begin to tug with all their might in opposite directions. Presently they take a rest and confer together. They decide that something is wrong, they can't make out what. Then they go at it again just as before. Same result. Mutual recriminations follow. Evidently each accuses the other of being an obstructionist. They warm up, and the dispute ends in a fight. They lock themselves together and chew each other's jaws for a while, then they roll and tumble on the ground, till one loses a horn or a leg and has to haul off for repairs. They make up and go to work again in the same old insane way, but the crippled ant is at a disadvantage; try as he may, the other one drags off the booty and him at the end of it. Instead of giving up, he hangs on, and gets his shins bruised against every obstruction that comes in the way. By-and-by, when that grasshopper leg has been dragged all over the same old ground once more, it is finally dumped at about the spot where it originally lay. The two perspiring ants inspect

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it thoughtfully, and decide that dried grasshopper legs are a poor sort of property after all, and then each starts off in a different direction to see if he can't find an old nail or something else that is heavy enough to afford entertainment, and at the same time valueless enough to make an ant want to own it. . . . Science has recently discovered that the ant does not lay up anything for winter use. This will knock him out of literature to some extent. He does not work except when people are looking, and only then when the observer has a green, naturalistic look and seems to be taking notes. This amounts to deception, and will injure him for the Sunday school. He has not judgment enough to know what is good to eat from what isn't. This amounts to ignorance, and will impair the world's respect for him. He cannot stroll around a stump and find his way home again. This amounts to idiocy, and once the damaging fact is established, thoughtful people will cease to look up to him, the sentimental will cease to fondle him. His vaunted industry is but a vanity and of no effect, since he never gets home with anything he starts with. This disposes of the last remnant of his reputation, and wholly destroys his main usefulness as a moral agent, since it will not make the sluggard go to him any more." You see even Mark Twain is compelled to pin his moral at the end of his tale. There is, however, one among many good points in Mark Twain's story that commends itself to us. He blackguards the ant through the whole gamut, yet no individual ant feels aggrieved at his personalties. When the writer on technical subjects does not, as well as when he does, touch the question of personality, someone is sure to fit on the cap and say the remarks were directed against him. It is necessary, then, to guard ourselves, and to say that in what follows no individual is aimed at or thought of: the general question alone is discussed. In our view—restricting that view for the moment to London—the analogue of the grasshopper's leg is the profit from the public who want light and power; the analogue of the ants is to be found in the companies who are all pitching their tents in one district, and going to pull at that profit from each and several standpoints. Result, after struggles greater in proportion than those of the ants : disputes, legal fights, and—none of the profits. Details are unnecessary. In several parts of London two or more companies are preparing for competition. If they think this business-like, and leading to long-continued prosperity, their views differ from ours. Overhead wires except as pioneer wires will not be tolerated beyond a certain point, and householders will not put up with having the paths and roads in front of their places of business pulled up to suit the convenience of competing companies. Two or three competitors in the same street means far greater initial expense, increased cost of maintenance, and revenue per unit cut down to the uttermost farthing in order to get all the trade possible. What is happening now on a small scale, will happen on a larger. Private installations are being connected with central stations, and the small central stations will by-and-by be connected to the larger ones. The expense gone to at some of these small central stations will never be recouped, for they will have to give way long before they have paid for themselves. The gas companies imagine a maximum supply as will be required in the future and lay mains accordingly, the electric companies lay mains for the minimum supply and have little margin for increase; the latter act as if they expected a short and merry life, while the former act as if they meant to stay. No doubt the refusal of the Board of Trade, so far as London is concerned, to grant licenses, and to act only by provisional orders, is an attempt to restrict company action within definite limits, but central station work requires neither license nor provisional order. Any company can at any point install a station, whether the ground is already occupied or not, and if it can obtain the requisite wayleaves and orders, can get to work. We had intended to obtain a moral from almost every sentence in Mark Twain's tale, but perhaps that we have indicated is sufficient for the present to provide thought for the thoughtful. Unfortunately, every company imagines that its peculiar position or the influence of its directors places it in a more advantageous position than any other entering into competition, therefore the plainest sermon with the most direct lesson is not likely to have much effect.

It will be admitted that in the abstract we are right, while in the concrete a few energetic men think they can see a way to make money, and, like the ant and his prize, their friends flock in to help carry away the money in view. They don't always get it, but that is a mere detail. Prospectively, then, if these schemes are persisted in, there are troubles and squabbles ahead, and plenty of work for the legal fraternity in London. But, bird of evil omen, avaunt! Turn we now to something of a more pleasing character. The past year has been one of revival in the electrical industries. On every hand we hear of work completed, in progress, and contemplation. Dozens of small and large central stations are in progress, the most important of which is that at Deptford, belonging to the London Electric Supply Company, while the Metropolitan Company is hurrying forward several smaller stations, which, however, in the aggregate will be of no mean capacity. Kensington, Chelsea, Notting Hill, Westminster, St. James's Oxford-street, Holborn, the City, in North London, and elsewhere about the metropolis, stations are being erected or designed. Before the middle of this year we fancy an aggregate of at least

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a million lamps will be provided for. We could wish that one half as much attention was being paid to the distribution of power as is being paid to the distribution of light, and then, with due consideration against excessive competition, there would be such a development of the industry as never was seen in any industry before.

The rapid increase of central stations for the distribution of light and power will necessitate some conclusion being arrived at with regard to overhead wires. At the present time a special committee has been appointed by the General Purposes Committee of the Birmingham Corporation to consider this question. Among all the conflicting utterances which have appeared upon this subject, the suggestion of Lord Crawford seems perhaps to be the one which will best solve the problem. We have already referred to this in a brief note, but the idea cannot be too much discussed, and we trust the Birmingham committee will give it due consideration. Undoubtedly the ultimate place for all wires connected with the electrical industries will be underground, so far as these wires are laid in populous centres, but to insist upon their being placed underground from the commencement might, and probably would, act disadvantageously to the development of the industry. Suppose a central station started with orders for lights in the immediate vicinity and with one or two orders at a considerable distance, the mains immediately surrounding the station where the great bulk of the lights are required, should be placed underground; but no business men would be tempted to invest their money to supply the individual orders at a distance if it were necessary to go to the expense of allowing heavy mains the whole distance underground. Lord Crawford's suggestion is to the effect that the supply company should be permitted in cases of this kind to run, temporarily, overhead mains to supply these distant points, and probably there would be a gradual desire along the line to add to the number of lights to be supplied. In a short time the demand would be perhaps sufficient to warrant the permanent mains being laid, but at any rate there should be a limit to the time during which the temporary wires might be used. The limit suggested has been three years, but it seems to us that if some such scheme as this were adopted it would benefit not only the trade, but those who desired to obtain the light and the power as quickly as possible. Readers may moralise upon the two points—"Excessive Competition" and "Pioneer Overhead Wires."

Before passing in review the work of individual firms, there is just one other question we should like to refer to, and that is the unfair manner in which our contemporaries devoted to gas, criticise electric lighting. We shall have something to say relative to Leamington and Barnet next week. Our contention is that the lighting in both places is better than it was with gas. Those who can only damn altogether or damn with faint praise are those whose inspiration is drawn from tainted waters, or who have received no inspiration at all other than their own inner consciousness. We have made it our business to send special representatives over and over again to see the lighting at one or the other place, and in every case the conclusion has been favourable to the electric light.

The following brief information about the work of individual firms shows that most of those engaged in the industry have been fairly busy during the past year, and that the prospect for the ensuing year is good:

Anglo-American Brush Company.—This corporation has been pioneer during the past year of very extensive and enterprising work both at home and abroad. The great resuscitation of the electrical industry following close upon the amendment of the Electric Lighting Act has had the effect, as was fully expected, of creating a demand for the supply of current for light and power from central generating stations. Foreseeing this, the corporation have studied carefully and successfully the production and perfection of the most efficient and economical plant for the purpose. So far from limiting themselves to any particular system of generation, they have noted the requirements of each individual case, and have installed the most suitable system in each instance. Their central station installations afford examples of the high-tension alternating current system, the low-tension continuous current system, the high-tension continuous current system, and also of the high-tension continuous current system in conjunction with accumulators.

The corporation's alternating current system has been eminently successful, and the demand for its adoption has so increased that they have found it necessary to equip their works for the more extensive production of this apparatus. This system is well exemplified by Messrs. Pritchett and Company's Oxford-street central station, Rathbone-place, Oxford-street, which has worked successfully for nearly a year, and has given entire satisfaction. We are informed that they now have orders in hand for apparatus of this system for installation in a number of central stations both in the United Kingdom and abroad, amongst which may be mentioned those of Lynton and Okehampton in Devon and Tucuman in the Argentine Republic. The central station at Bournemouth, on which the corporation are now engaged, will be worked by the Mordey Victoria alternators, which will, in the first instance, supply 2,000 lamps of 17 c.p., an output that can be increased whenever the demand calls for its extension. We understand that the corporation will supply their machinery and apparatus to the central station of the Chelsea Electricity Supply Company, which is now approaching completion. The apparatus will be worked in conjunction with E.P.S. accumulators, and it is believed that this installation will be a model for central stations on the system of accumulator distribution. An interesting example of central station low-tension distribution has been carried out by the corporation through their Italian agent at Novara; it is on the three-wire system, and has operated so successfully that it has been decided to considerably increase the capacity of the plant.

In exhibition lighting the work of the corporation maintains its excellence. The installation carried out by them at the Glasgow Exhibition of 1888 comprised over 500 arc lamps, by which the exclusive lighting of the main building and ground was effected, the whole of which lighting worked through the entire term of the exhibition without a single hitch, and was universally admired. Incandescent lamps were also supplied to numerous private

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consumers from their exhibit installation. In the Melbourne Exhibition of 1888 the corporation also supplied, through their Australian agents, the whole of the lighting plant, comprising dynamo machines and all accessories for an installation of about 800 arc lamps of 2,000 c.p., and machines for 3,000 incandescent lamps of 17 c.p., the illumination being most satisfactory, and the plant supplied running uninterruptedly throughout the six months. The fact that the whole of the apparatus for this large installation was constructed and shipped under a penalty contract within six weeks from the date on which the order was placed, affords a comprehensive estimate of the corporation's resources in the designing and expeditious manufacture of their plant. We should also mention that at the Barcelona Exhibition of 1888 a most successful "fairy fountain" installation was carried out by the corporation, which proved a great attraction, and is generally considered to be the most perfect example of the kind that has yet been effected. In ship-lighting, business has been fairly brisk, and among the larger contracts which they have carried out in this branch are those for the complete lighting of the "Rosslyn Castle," the "Norham Castle," and the "Hawarden Castle," vessels belonging to Sir Donald Currie and Co. A number of their combined plants, constructed for installation on shipboard, have also been supplied to the Pacific Steam Navigation Company, Liverpool. This apparatus is very compact, and the corporation have supplied a large number of sets to the principal European Governments for installation on shipboard, and other situations where economy of space is a consideration.

In the design and construction of motors and other appliances for the electrical transmission of power they have bestowed much thought and attention, and, amongst other undertakings, they have entered into a contract for the application of electricity by overhead conductors to an extensive tramway system in Spain, which presents features of exceptional difficulty in sharp curves, steep gradients, etc.

From a large number of installations in public buildings, mills, factories, mansions, etc., carried out during the past year, we may select as particular instances the following: Blenheim Palace, the residence of the Duke of Marlborough, and "Clova," Ripon, the residence of Prof. Piazzi Smythe.

In export trade the corporation have done a large business, shipping their apparatus to all parts of the world.

The famous action of the Edison-Swan Electric Light Company *v.* Holland and others, defended by the Brush Corporation, has now become matter of history, and the decision of the court in the appeal which has followed the action is awaited by the corporation with every feeling of confidence.

In the case brought by them against the Orient Steamship Company for the use of dynamos which infringed the Brush Corporation's compound-winding patent, the judgment of Mr. Justice Chitty is of great importance, establishing as it does the validity of their patent, which, though acknowledged by all the principal dynamo makers in this country, had not been contested in a court of law.

Their Scottish action with reference to compound winding has only been partly heard, but will probably be determined at an early date.

GOOLDEN AND CO.—Messrs. W. T. Goolden and Co. have had a very busy year, not having experienced slackness in the summer months, which has been a usual experience in former years with electrical manufacturers. They have been occupied with considerable orders for the Admiralty and India Office, in theatre lighting and mill and house installation work, and have been very busy with installations for transmission of power. Alternating-current plant—both dynamos and transformers—have been added to their list of productions some large alternating machines having been built. They have also been engaged in tramway work, utilising waste water-power. In the instrument department a corresponding activity has prevailed, and the "Evershed" and "Cardew" instruments have met with considerable appreciation from contractors as well as private customers. In order to cope with the great increase of business, they have recently removed into large and commodious premises in Woodfield-road, Harrow-road, London, specially arranged and fitted for the business, and have largely increased their plant, with a view to producing machinery and electrical instruments, and other work, on the most modern system of manufacturing.

HAMMOND AND CO.—During the past year this firm has continued to devote itself almost exclusively to central station lighting. They have considerably enlarged their operations at Brighton and Eastbourne. At the latter place they are still working, as they have been working for the past six years, with a system of underground mains for high-tension currents, which system is attracting at the present time a great deal of attention; the installation there being probably the only one in the world where such an extensive area is served by means of underground mains.

They have also in the past year founded the House-to-House Electric Light Supply Company, which bids fair to take a very good position in the electric lighting world, and has distanced all its rivals by the rapidity with which it laid down its Kensington station. On the last day of the year the boilers and engines started to run, and the current can now be supplied. A full description of these works will appear in a later issue.

Hammond and Co. have already been chosen by the Great Northern Railway Company to do their electric lighting at the new shops in course of erection at Doncaster.

IMMISCH AND CO.—During the past year Messrs. Immisch and Co. have been steadily increasing their business.

There has been an increased demand for motors for isolated installations, but motors used in connection with central stations do not seem to be in demand. This, however, will probably be altered as the number of central installations increases.

The firm have given particular attention to motors for mining purposes, and have three plants ready for erection now—one in Yorkshire (a repeat order), one in South Wales, and one in Scotland.

Experiments have also been made with a self-contained loco. at Wharncliffe-Silkstone Colliery, Yorkshire. The results are very promising, and seem to argue well for this class of traction. Attention has also been given to the application of motors to launches, and considerable progress has been made. At Henley last year the firm had a 30ft. launch called the "Malden," and since then have placed on the Thames the "Viscountess Bury," a superbly fitted pleasure boat 65ft. long, 10ft. beam, and a mean draught of about 3ft. This latter launch is specially designed for the accommodation of pleasure parties. She is fitted with twin propellers and motors, and will make about six knots an hour from some 10 to 12 hours. It is intended to place on the river a fleet of about eight to ten launches, most of which are now building, in the early part of the year, which will be let out on hire to pleasure parties. For the purpose of charging the accumulators, charging stations are being established at several points on the river, and there are two floating stations that can be moved to regattas or anywhere as may be required. Messrs. Immisch and Co. have supplied the five motors used on board the Spanish submarine boat, the "Peral." They have also supplied the dynamo for charging the 600 accumulators used for storing the energy. The firm has also been engaged with tramcar motors, several of which have been made for foreign orders. Six of these motors are being supplied to the Electric Traction Company for use on the North Metropolitan line between Canning Town and Barking. They have also made a dynamo of special design for charging the accumulators for the six cars. It is expected that the whole will be running by the middle of January. A fair number of dynamos have also been supplied by the firm for incandescent and arc lighting both at home and abroad. There has also been a considerable increase in the general work of the firm, and orders have been received for motors to be used in new directions, and this shows that the users of power generally are beginning to find out the value of this system.

LAING, WHARTON, AND DOWN.—This firm commenced the year at new and more commodious premises in New

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Bond-street and Brook-street, and have found the move from Holborn-viaduct to be in every respect a good one. They have carried out a great deal of work, both large and small installations, and their staff is very much increased, so that their new premises are in some respects too small already. This refers more particularly to the showroom for artistic electric fittings, which was originally thought to give ample room, but there has been so much increased electric lighting that the demand for fittings has, of course, developed very considerably, and also the taste of the public has improved, and the old day of converted gas-brackets, etc., is rapidly disappearing. The firm finds that customers are becoming alive to the fact that the electric light can be charmingly combined with art.

The Thomson-Houston system, for which Messrs. Laing, Wharton, and Down are the agents, has made considerable strides in this country during the past year, and considerable contracts are being carried out for railway and dock companies, engineering works, breweries, etc. The installation on this system at the Italian Exhibition was extremely successful in every way, the 300 arc and 400 incandescent lamps having run without a single hitch for the six months. This installation naturally attracted a great deal of attention, and led to numerous enquiries and a considerable amount of work. The firm is to be congratulated in being able to say that in no single instance where a Thomson-Houston machine has been installed have they ever had the slightest complaint.

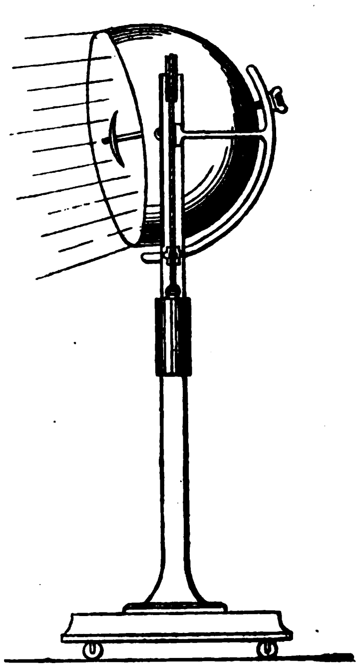
Mather and Platt.—The electrical engineering department of Messrs. Mather and Platt, of the Salford Iron Works, Manchester, has been very actively employed during the past year; the number of dynamos turned out has largely exceeded that of any other year. Among the more important of the installations for which they have manufactured the dynamos, we may mention the following: For the Adelphi Theatre, London, two large dynamos, each for an output of 1,300 lamps, and two smaller dynamos, each for an output of 800 lamps, all of the Edison-Hopkinson type, and driven by Willan's central-valve engines; two Edison-Hopkinson dynamos, for the central station of the Leeds Corporation, including the lighting of the Leeds Art Gallery and Municipal Buildings; two slow-speed Edison-Hopkinson dynamos, each of 1,000 lamps, for the mills of Messrs. Eckroyd and Co., Burnley; a special low potential Edison-Hopkinson dynamo, for Mr. Webster's new process of treating sewage. The firm has also supplied 15 dynamos for the Admiralty in conjunction with Willan's central valve engines and Westinghouse engines, and have manufactured the dynamos for Lord Rothschild's yacht, for lighting Lord Rosebery's country residence, for lighting the chemical laboratory at the University of Cambridge, as well as a very large number of dynamos for ship lighting, country house installations, and especially for cotton mills and weaving factories in the colonies and abroad.

Robey and Co.—Closely connected with electric lighting is the construction of good engines for driving dynamos. A number of firms are coming prominently into notice as makers of suitable engines, and, among others, we may mention Messrs. Robey and Co., who, at the Newcastle Exhibition of 1887, and at the extremely successful Glasgow Exhibition of last year, had a large display of engines. At the latter exhibition they had eight different engines of various classes specially suitable for electric light work under varying conditions. Among others, vertical and horizontal engines, with all their working parts running in a bath of oil, specially for ship lighting and other places where attention cannot be given to them; a small compound engine, only occupying about 4ft. square, and developing 30 h.p. at 500 revolutions per minute; and for permanent installations a 300 h.p. engine, which proved its thorough suitability for the work, by not only doing its own duty, but frequently that of its neighbours, during the whole of the exhibition without a moment's stoppage from any cause whatever. During the year the firm have supplied many engines for private installations, and work in this department has very considerably increased. Amongst them are a number fitted with their new class E trip gear, which has been illustrated in our pages, and also with their patent electric regulator. They have a number of engines on hand at the present time of large size working up to 250 h.p. each, three of them going, to a large electric installation in Australia, the machines for which have been manufactured by Messrs. Elwell-Parker, Limited, Wolverhampton, and as an illustration of the wide diffusion of electric light, Messrs. Robey and Co. are just supplying an engine and boiler for working 300 lights to a Roman Catholic monastery in Scotland. The firm expresses no doubt that electric lighting has become established on a commercial footing such as it never before occupied, and the demand for it is constantly increasing.

The Telegraph Manufacturing Company, Helsby, near Warrington, have been fully employed throughout the year. Insulated wires—both gutta-percha, indiarubber, silk, and cotton—are the chief articles of manufacture, and nearly 7,500 miles have been turned off during the year. Vulcanised rubber, electric light leads, for which the company have erected special plant, are being sold with first-class results, the shops now working overtime. The company have made during the year over a thousand railway telegraph instruments, also a large number of instruments for the postal telegraphs department, including automatic bi-polar relays, sounders, double current keys, single needle tapper commutators, etc. Domestic apparatus has also been sold in large quantities. The company have special facilities for turning out work of this class. The new patent telephone-magneto is in great demand, as also telephone material generally. The other departments—battery and insulator—have been constantly employed throughout the year.

PHOTOGRAPHIC ARC LAMPS.

In photographers' studios a great desideratum is that of a strong, convenient light suitable for taking photographs after dark, or on foggy days. The arc light has some very considerable advantages for taking photographs, and these in several cases have led to fashionable artists installing their own gas-engines and plant; in other cases the supply has been obtained from central stations.



Faraday's Photographic Arc Lamp—Standard Pattern.

We illustrate herewith two arrangements for arc lights for photographers, constructed by Messrs. Faraday and Son, Berners-street, specially adapted for this purpose, one a hanging lamp, and the other a standard form of the same. The hanging lamp has been fitted at Mr. Bassano's studio in Bond-street, and consists of a large parabolic papier-maché reflector slung in the same manner as Sir David Salomon's "Perfect Pendant," manufactured by the same firm, with three cords of suspension, allowing of

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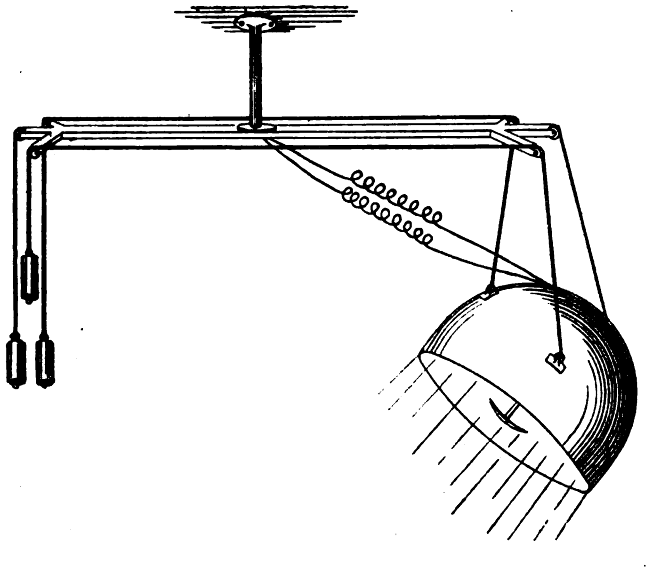
motion up and down and alteration of direction in any angle. The reflector is counterbalanced by weights, each having an eyelet for easy manipulation by a hook, and the whole can be rotated upon a pivot, arranged at the bottom of the iron tube by which the whole is fastened to the ceiling.



Faraday's Photographic Arc Lamp—Sling Pattern.

The standard lamp shows a similar parabolic reflector, fitted so as to be adjusted up and down, and to be pointed in any direction. It is mounted upon a movable frame with castors by which it can be wheeled about the studio. The arc lamp used is constructed to work at any usual angle. The lamp requires about 30 amperes, and is about 5,000 nominal c.p.

TRAMWAY WORK.

In continuation of the information on the Bentley-Knight system, described at some length in our last issue, we give the gist of a pamphlet compiled by this company, and in the accompanying tables we give estimates as to the cost of a tramway on this system in New York.

It is the tendency of modern practice to concentrate the generation of power into large stationary plants where the utmost economy can be obtained. Power, heat, and light are all at the present time distributed from central stations by means of steam, gas, and electricity, the main contribution of the latter to modern industry being its adaptability to the distribution of energy from a central generating point.

In considering the application of electricity to locomotion, it must be viewed as a means of transferring energy from one point to another; the problem being to divide up the energy of a steam-engine at a station among the cars on a line, and to enable each car to receive and utilise, as it moves, the proper amount of current for its needs at any given point. In a cable railway, distribution of power is accomplished by a rope constantly dragged by the power of the engine over the whole length of the line, the cars gripping it at will. In an electric railway, the energy of the engine is converted into electricity and carried by stationary metallic conductors along the whole length of the line, and the cars, as they move, draw off the electricity by means of a constant sliding connection between each car and the conductors.

The electric current passes along its conductor without outward manifestation; there is no friction, no inertia, no appreciable heat; it can be taken off at any point and converted into power or into light. An idea of electricity, as a medium for transferring energy, may be had by remembering that an electric arc lamp represents about three-quarters of 1 h.p. of energy. If a lamp is removed from the circuit and replaced by a motor, we have the same energy in the form of motive or mechanical power. In some smelting furnaces electric heat is employed. A certain small amount of energy is lost in the conductor through which the electric current passes, heat being generated and radiated, but this loss in a well-constructed electric line never exceeds 5 per cent.

While the conveyance of electric power by means of a rod or wire of copper is very simple, it is a very difficult mechanical problem to convey the same amount of energy by a wire rope, as in the cable system. The weight of the cable must be moved, and it must be supported by sheaves placed along the line at short intervals, while a large tunnel must be built to contain it. The sheaves all consume power, must be constantly oiled and watched, and prevent any thorough cleansing of the conduit. Elaborate and complicated construction is necessary for curves and switches, while the connecting and disconnecting of a heavily loaded car to and from a swiftly moving cable is a difficult and wearing process. Cable engineers estimate that more than 75 per cent. of the engine-power is consumed in moving the dead-weight of the cable, and the cable itself rarely lasts a year.

When electricity is used, on the other hand, the conduit contains only stationary and permanent copper rods, and no mechanism is employed which can wear and give trouble. Connection between the motor on the car and the current supply in the conduit is maintained by means of a light sliding contact bearing gently against the conductors, and the conduit excavation need be only large enough to permit of drainage. So far as the transmission of power is concerned, the simplicity and convenience of the electrical method are unrivalled.

Its efficiency is equally satisfactory. The dynamo-electric machine, by which the power of the steam-engine is converted into electricity, has reached a degree of perfection scarcely appreciated. Less than five years ago the best dynamos gave an efficiency of 75 per cent.; there was an excessive heating of the wire coils and of the journals, so that a machine could rarely be depended upon for a run of 12 to 18 hours at a stretch. There were frequent burnings out of the armature and of the commutator, and other recurring faults which caused uncertainty and expense. At present the best manufacturers sell their machines, both dynamos and motors, with a guaranteed efficiency of 90 per cent; so that for every 100 h.p. of the steam-engine, 90 will appear on the line in electricity, and 81 will appear in the motor in the form of mechanical energy. The latest series of tests made with railway motors demonstrated an efficiency of 80 per cent. from the steam-engine to the car-axle. From this must be deducted in actual practice 5 per cent. for the conductors and 10 per cent. for contingencies of all kinds, leaving 65 per cent. actually to be relied on. Therefore, from 100 h.p. at the engine, 65 will be delivered on the car-axle.

The capacity of machines has increased in like ratio. A machine that would formerly operate 35 or 40 arc lamps has been worked up to operate 65. At the same time the reliability of machines has been improved. Their electrical and mechanical construction has been brought to such a degree of perfection that little more can be desired. While the electrical machines have been worked up to this point, special engines for driving them have been designed, and special appliances devised for protecting both dynamos and engines from all possible accidents and interruptions. This growth has been unostentatious, but rapid and sure, and at present the transmission of energy by electricity is thoroughly and completely practicable, thousands of horse-power being every day obtained from electric motors.

The application of the motor to railway use has been steadily developed during the last four years. Various difficulties have been met and overcome. The conduit system, involving greater difficulties and expense than the overhead system, has gone somewhat slower, but both are now in shape for practical everyday use. The peculiar adaptability of the electric motor to railway use is not fully appreciated except by those intimately acquainted with it.

The work of propelling a tramcar is characterised by wide variations in the amount and character of power required. The work is measured by the product of the

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ESTIMATES.—*Average Prices for New York City.*

The following estimates are all made for a road five miles long, double track, operating 40 cars ; average speed, six miles an hour ; headway, 2½ minutes ; maximum grade, 5ft. in 100 ; 16 full running hours per day.

CONSTRUCTION AND EQUIPMENT.

	Horse.		Electric.		Cable.	
10 miles track	at $7,000	$70,000	at $7,000	$70,000	at $7,000	$70,000
40 cars*	at 850	34,000	at 700†	28,000	at 950‡	38,000
400 horses	at 150	60,000	—		—	
10 miles conduit	—		at 25,000	250,000	at 65,000‖	650,000
Steam plant	—			20,000		25,000
Dynamo plant	—			24,000	—	
40 motor trucks	—		at 1,500	60,000	—	
Machinery and sheaves	—		—			10,000
Building		40,000		10,000		10,000
Total		$204,000		$462,000		$803,000

ANNUAL RUNNING EXPENSES.

	Horse.		Electric.		Cable.	
Feeding, replacing and caring for 400 horses	at $219	$87,600	—		—	
Coal, at $2.50 per ton	—			$7,756		$9,581
Engineer and assistant, at $2.50 and $1.50	—			1,460		1,460
Firemen, two, at $1.50	—			1,095		1,095
Oiling sheaves	—		—			4,000
Wear and tear	at 5%	7,200§	at 3%	13,860	at 3%	23,694¶
Maintaining cable	—		—			13,200
Interest, at 6 per cent.		12,240		27,720		48,180
Total		$107,040		$51,891		$101,210

* Car-bodies cost from $700 to $1,200. † Axles and wheels are included in motor-trucks. ‡ Including grip. ‖ From $50,000 to $100,000 per mile of track. Curves, crossings, and switches constitute a heavy additional expense. § $204,000 less $60,000 (cost of horses) ¶ $803,000 less $13,200 (cost of cable).

traction into the velocity, and there is found to be a variation in the total product required, and also a variation in each of the factors entering into it. A motor for street-car work must be capable of wide variation in traction, to correspond with the variations in grade on the line. The quite ordinary grade of 5 per cent., for instance, requires about eight times the traction that is necessary on a level.

For this reason motors that have but little range of pull or pressure must fail; for while, on a level, the pressure will be ample for the load, and will accelerate the speed so as to do a large amount of work, it will not give sufficient traction for a grade or curve. In an electric motor, on the other hand, the pull increases as the square of the current, and is limited only by the magnetic saturation of the iron cores. This limit is so remote that it is best appreciated by the fact that, in practice, a motor capable of moving 15 tons up a grade of 8 per cent. weighs, with its gearing, but 1,600lb. By admitting three times the current to the motor that is necessary on a level, the traction can be increased nine times.

It is another peculiar feature, that the necessary increase of current automatically takes place by reason of the tendency of the electric motor to slow up under an increased load. This slowing tendency and the acceleration due to the resulting increase of current meet each other at a point always dependent on the load at any given time. This follows from the following considerations: A dynamo and motor are the same machine working in converse ways, the dynamo converting mechanical into electrical energy, and the motor converting back electrical into mechanical energy. When acting as a dynamo, the machine has also a motor action, due to its own current, which opposes the driving-engine, and in overcoming which the power of the engine is consumed. When acting as a motor, on the other hand, it has also a dynamo action, tending to set up an E.M.F. against the direct or actuating E.M.F.

The efficiency of the transmission depends on the ratio between the direct and counter E.M.F's.; and, as the resistance of the motor is constant, the current through it will depend on the excess of one over the other. Any slowing of the speed, therefore, causes a large current to pass through the motor; and this produces a much greater traction, since the traction increases as the square of the current. There are other elements which come in to modify this result somewhat, but which we need not enter into. As a fact in practice, the traction automatically increases in a much greater ratio than the speed decreases, corresponding very closely with the variations in traction and speed that the service on most short railways demands. For the large majority of cases, therefore, the electric motor is nearly self-regulating, an artificial resistance being used for stopping, and occasionally for going very slow and restraining too high speed.

The great capacity and compactness of the electric motor are evident qualifications for tramway work.

ON THE ABSOLUTE VACUUM AS A NON-CONDUCTOR OF ELECTRICITY AND THE IMPORTANT BEARING OF THE FACT UPON ELECTRIC THEORIES.*

BY DR. P. H. VANDER WEYDE.

The historical exhibition which I furnished at the American Institute Fair of 1887 contained several series which for want of space could not be separately shown, as would have been desirable, if space had permitted. In fact, everything was to a great degree mixed up for the reason referred to.

Among these series electricity in vacuo formed a prominent and important feature, and because this is a subject so little understood, and even misunderstood, by the majority of electricians, and is also neglected in the text books, I felt induced to take this for my subject when I was requested to address the society.

An additional reason was that it is of some practical importance, not so much in regard to its mechanical applications, as for the understanding and explanation of a great number of natural phenomena.

I will treat the subject historically, and therefore begin by calling your attention to the experiments of Nollet, recorded in this little book, published in Paris 1753, and illustrated with carefully engraved figures. His experiments consisted in passing a current of static electricity through glass flasks, from which a large portion of the air had been previously removed by the air-pump. He found that the electric current passed as a luminous stream which was very bright when the room was darkened, while luminous pencils were thrown off toward the side of the flask if they were touched by the fingers or any other conductor of electricity.

Some thirty years later a variation of this experiment was contrived, consisting of a strong glass tube of about

* Paper read before the New York Electrical Society.

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two or three inches diameter and three or more feet long, provided with brass caps at each end, which could be conveniently attached to the air-pump, and exhausted. As the exhaustion proceeded, the rarefied air in the tube became a conductor of electricity, while this conductivity appeared to improve in proportion as the air was more exhausted. At last a regular stream of electricity was seen to pass through the tube, which stream resembled strikingly the luminous coloured streams seen in the aurora borealis, wherefore such a tube was called the "aurora tube," and under that name is found in most philosophical collections.

This apparatus was exhibited at the fair, the exhibit consisting of an old historical air-pump, made about 1780, with the aurora tube screwed on the top of it. A few other smaller devices of a similar nature were less conspicuous, and about them I wish only to remark that when using an ordinary air-pump it appeared that the conductivity of the air increased in proportion to the amount of exhaustion; hence the impression became prevalent that if we could only obtain a perfect vacuum we would have the best of all conductors, and this idea is, unfortunately, even at the present day, shared by several prominent electricians who have not had the opportunity to keep themselves posted in regard to the discoveries made during the last few years, especially those made by Crookes, Gassiot, Spottiswoode, Gordon, and others.

I must not omit to mention that before the latter discoveries Geissler, in Germany, began to furnish investigators with a great variety of glass tubes of various fanciful shapes, made of different kinds of glass and filled with various gases and vapours, exhausted by the air-pump or by being heated, and then sealed up by the blow-pipe, while platinum or aluminium wires were inserted at the extreme ends, so as to conduct the electric current through the rarefied gases inside. As those tubes exhibited a series of striking and beautiful phenomena, they became very popular, and no physical collection is considered complete without a set of such tubes. They give occasion to exhibit the auroral phenomena, and similar ones of the same character, without the trouble of continually working the air-pump.

I had two sets of such tubes on exhibition at the fair—one was extra large, the tubes being three and four feet long, and another set of tubes as many inches in length, and which I shall have the pleasure to exhibit to you tonight, being much easier and safer to transport than large tubes.

I will now proceed to make a statement of the facts as they are. They are startling and difficult to explain without the knowledge of the new conceptions of Prof. Crookes regarding the nature of matter in the four different conditions, in which it presents itself to us.

The facts referred to are: The atmosphere in its ordinary condition is a very good non-conductor of electricity, provided it is perfectly dry and under a pressure equal to a mercurial barometric column of 760 millimetres or higher.

It is an important consideration, that if the air in which we live were a good conductor of electricity, man could never have become acquainted with electrical phenomena, as then static electricity could never have been collected, studied and experimented with; as this form of electricity was the key to the other different forms, the latter would never have been discovered.

When rarefied by the air-pump to a quarter of the normal pressure, the insulating qualities of air are not so good, and when reduced to a pressure of 10 or 20 millimetres it is a good conductor, and exhibits the phenomena referred to before. As this is about the limit attainable by an ordinary air-pump, it is very natural that experimenters became possessed of the idea stated above, that the conductivity of the air would keep on increasing as the exhaustion proceeded; but after the Sprengel mercurial air-pump was invented, by which the air can be exhausted to a thousandth of a millimetre of mercurial pressure (which is about equivalent to one-millionth part of ordinary atmospheric pressure), it was found that the capacity of the air to show the auroral phenomena in the usual way ceased.

The electric current then behaves in a very different manner, as it radiates in straight lines and cannot turn corners, so so when the tubes are bent it gives occasion to very striking and novel phenomena, which were first brought forward by Prof. Crookes in the tubes which are known by his name.

The difference between the Geissler tubes and the Crookes tubes is, that in the first the vacuum is very imperfect. In the Crookes tubes it is about a thousand times better, while if we succeed in making the vacuum a million times better, the conductivity of the air ceases absolutely. To accomplish this we must aid the function of the Sprengel air-pump by some chemical device which will remove the last remant of air. It then becomes an absolute non-conductor, which ordinary atmospheric air is not, because it is possible to pass currents of high tension in the form of an electric spark through the densest and driest air. In the absolute vacuum, however, it is impossible to pass, over the space of a quarter inch, a spark which, when leaping through air, will be six or more inches long.

I exhibit here such a tube in which the two platinum wires are brought together within a distance of scarcely a quarter inch. In this tube a vacuum did exist so perfect that it was impossible to pass a spark through, which through air would leap over a distance of more than six inches. I found that the spark would rather pass over the outside of the tube for that distance than go through the interior. In order to satisfy myself that no trace of electricity passed through the interior space of a quarter inch, I connected one of the platinum wires with a Leyden jar, wound a brass chain half way around the middle part of the tube, and connected this brass chain with the ground, in order to prevent any electricity from reaching the Leyden jar through the air along the outside, but I was not able to obtain the least trace of a charge in the Leyden jar. Later, I increased the strength of the current more and more, until at last something happened in the tube which destroyed the vacuum; something volatilised, covering the sides of the glass interior with a blackish deposit, which may perhaps be platinum black—a thing which may not be impossible, if we consider that the electric discharge furnishes us the highest temperature which we can possibly produce by any means.

For more than 20 years I have preached this non-conductibility of a perfect vacuum, as it was proved by experiments with the Ruhmkorff coil, by de la Rive and Du Moncel. The latter describes the experiments in his book "Sur l'appareil d'induction de Ruhmkorff," published in Paris about 25 years ago.

It has not a little surprised me that the priority of this discovery is so remote as I found it to be, and that so important a fact as that of the non-conducting power of a perfect vacuum has been overlooked and ignored for nearly a century after it was proved by experiment. I found in the "Philosophical Transactions" for 1785, page 272, vol. 75, the extract of a paper read by Morgan before the Royal Society, and which I published eight years ago in the *Practical American*, which I edited at that time. The paper referred to states that a mercurial gauge 15in. long, filled with pure mercury which was boiled in the glass until all air was expelled, was coated with tinfoil five inches down from its sealed end, and was inverted into the mercury in a little trough, through a perforation in its brass cap: the air over the mercury in the trough was then exhausted, when the mercury in the gauge fell down more or less in proportion to this exhaustion, but had always a perfect vacuum over it. If, then, the tinfoil coating the upper end of the tube was connected with the conductor of an electric machine, not the smallest ray of light nor the slightest charge could be produced in this exhausted gauge; but if the mercury had been imperfectly boiled, coloured luminous phenomena were seen. The same was the case when the sealed end of a perfectly exhausted tube became cracked so that a little air had access. At first the electric charge passed with a yellow or green light; more air made the colour a beautiful green, then blue, from blue to indigo; more air still, violet and purple, until the medium became so dense as to no longer conduct electricity. The writer closes with the observation: "I think there can be little doubt, from the above experiments, of the

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non-conductive power of a perfect vacuum. This seems to prove that there is a limit even in the rarefication of air, which sets bounds to its conducting power; or, in other words, that the particles of air may be so far separated from each other as no longer to be able to transmit electricity; that if they are brought to within a certain distance of each other, their conducting power begins, and continually increases, till their approach also arrives at the limit."

It is also a fact, known for more than a century by expert barometer makers, that the luminosity which shows itself in the dark in its vacuum, when a barometer is moved up or down in order to cause the mercurial column to oscillate in the same way, is only seen when the mercury has been boiled in the tube to a moderate degree; when the vacuum is made too perfect it shows itself feebly, or not at all, the same as is the case when the vacuum is contaminated with watery vapours.

So much for facts; now for the theory which explains them, and for which we are indebted to Prof. Crookes. It gives us an inside view of the nature of matter in the conditions in which it presents itself to us, and is based on the theory of Dalton, that all matter consists of an immense number of infinitesimal particles called atoms, which are indestructible, and in continual motion, which latter is also indestructible.

Astronomy teaches that in the planetary system we find a condition of things which is far beyond our ordinary conception based on our experience about things falling under the daily, immediate observation of our senses. First, the distances at which the celestial objects are placed are immense in proportion to their size, stupendous as it appears to us. Secondly, they are in a continuous motion, which is indestructible. Every planetary system is to us a perfect "perpetuum mobileo."

Modern chemistry teaches the same doctrine in regard to ultimate atoms, which constitute that which we call matter. First, the distances of these atoms are also very large in proportion to their size, which is infinitesimally small beyond our conception; secondly, these small particles or atoms are also in a continuous everlasting motion, as indestructible as is the motion of the planetary bodies.

As a concise statement of the modern philosophical conceptions in regard to this subject, we say that, as the chemists of the past century proved, that apparent destruction of matter was only a transmutation of form, so the physicists of the present century have proved that apparent destruction of motion is also merely a transmutation of form, a change in the mode of motion; mass motion changed into molecular motion, which reveals itself as heat, light, or electricity, or, *vice versâ*, any of the latter forces into one another or into mass motion. Of this transformation the steam-engine and the modern dynamo are forcible illustrations.

The great Swedish chemist Berzelius, more than half a century ago, expressed similar views when he declared that the heat and light we see in an electric discharge, say, in a stroke of lightning, is not the electricity itself. He states most explicitly that the restoration of the electrical equilibrium, which when destroyed gives rise to what we call electrical phenomena, causes the evolution of sudden light and heat in the bodies through whose medium this restoration of equilibrium takes place, which light and heat then radiates and diffuses itself according to the ordinary well-known laws of radiation and convection.

Crookes, in order to explain the peculiar behaviour of electric discharges through his highly exhausted tubes, teaches the doctrine that our conception of three states of matters—solid, liquid, and gaseous—is incomplete; he says that there is a fourth condition, which he calls radiant matter. He teaches as follows:

In solid bodies the atoms are in a state of rest—that is to say, as far as their relative position is concerned, but each atom oscillates to a greater or lesser degree. If the amplitude of the oscillation is small, we call the body cold; if the amplitude of the oscillation is large, we call the body hot, and, in so far, Crookes' theory agrees with what Tyndall has popularised in his well-known work, entitled "Heat as a Mode of Motion."

When the amplitude of the oscillations becomes so great that the atoms turn over and commence to rotate around their centres, the body reaches its melting point and becomes a liquid. Therefore, in liquids the atoms are not rigidly fixed to certain positions, but can freely roll over one another, and this constitutes the difference between solids and liquids.

When the velocity of the rotation becomes greater and greater, we say that the liquid is becoming hotter, and when from some cause or other this motion is still further increased, a new set of phenomena begins. The atoms are projected into space, and in place of rotating they are propelled from the liquid, and also repel one another, and as millions upon millions exist in the small space of a cubic inch, collisions take place by billions, and the body enters in what we call the "gaseous" condition.

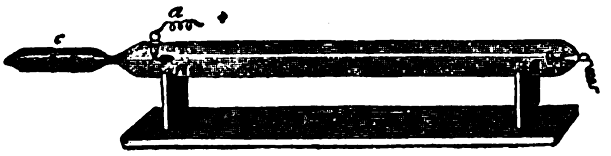

FIG. 1.

Here we have entered a field for the conception of which very few are prepared. We are as little prepared for it as our ancestors were when Galileo and Copernicus, and later, Herschel, revealed to mankind the immensity of the universe. When at school, studying astronomy, we obtained some kind of conception of the infinitely large.

We are not yet educated to the conception of the infinitely small, which is a new revelation, which is as difficult to grasp with our finite mind as it is to grasp the infinitely large. In considering the latter, we speak of distances so great that our common measures are utterly inadequate, and we must have recourse to larger standards of measures, such as the velocity of light connected with the time it takes to reach us from the most distant stars, which in some cases has been proved to be 10,000 years.

In considering the motion of the atoms of gaseous matter, we enter the other extreme of the conception of great and small. It appears that the number of atoms in one cubic inch of the common air we breathe is represented by a series of more than 20 figures, which particles or atoms are in constant continual collision to the number of ten million per second, while the velocity is so great that, if moving in a straight line, they would pass through a space

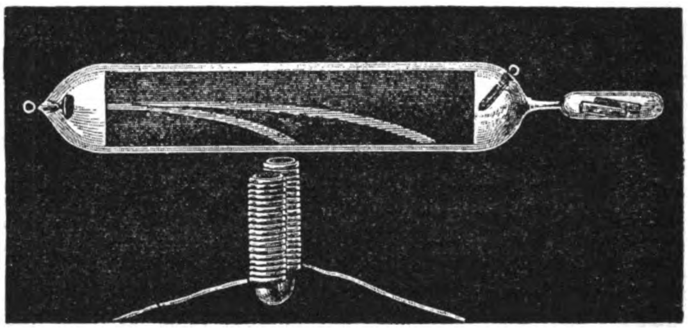

FIG. 2.

of 11,000ft. in a single second, thus surpassing the velocity of sound 10 times. This is the nature of the third or gaseous condition.

The fourth condition, attained by the Sprengel air-pump, is called by Crookes radiant matter. It is reached when the exhaustion proceeds so far that there are so few atoms left as to make the collisions exceptional; then the atoms will move in straight lines, and, encountering no mutual hindrance to their motion, they will follow the laws of electric repulsion and *radiate* from the point charged with electricity; hence matter in this condition is called "radiant matter."

Now we come to the most interesting feature of our consideration—namely, the chemical device referred to above, and intended to remove this last trace of air; recourse is had to the strong chemical affinity of potash for carbonic acid. The exhausted tube is filled with car-

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bonic acid gas and again exhausted, and this process repeated in order to make sure that no atmospheric gas is left, but only very rarefied carbonic acid gas. A recess is connected with the tube during the operation, in which recess is placed a small stick of pure caustic potash. This recess is heated by a spirit lamp, so as to drive out the carbonic acid which the potash may contain, and then the vacuum is again made. The last remnant of carbonic acid which the air-pump cannot remove is then absorbed by the potash, when this is allowed to cool down. In this way the absolute vacuum is produced, through which no electric current can be made to pass. Of the accompanying two cuts, Fig. 1 represents an arrangement similar to the tube exhibited at the lecture, while Fig. 2 shows that as the direction of the magnetic needle may be deviated by a wire conducting an electric current, *vice versâ*, the direction of a flow of an electric current in a partial vacuum will be affected by magnetic influence, as shown by the results of charging and discharging the electromagnet seen below the tube.

The bearing of this fact is of the utmost importance in regard to our conception of the nature of electricity. It is generally admitted that the theory of the existence of a caloric fluid is erroneous, and that heat is merely a peculiar mode of motion, as referred to above, and this view is adopted, notwithstanding there is no experiment known serving to demonstrate that heat cannot be transmitted through a space absolutely devoid of all matter. Heat and light will both pass through a vacuum perfect enough to obstruct absolutely the passage of electricity. If there were such a thing as an electric fluid, it surely would pass through any empty space, and we are therefore driven to the conclusion that the presence of matter is as absolute a condition for the transmission of electricity as the presence of air is an absolute condition for the transmission of sound; and there is as little necessity to accept the hypothesis of the existence of an electric fluid as there is for the hypothesis of a sonorous or caloric fluid.

Air being the ordinary vehicle by which sonorous vibrations are transmitted, a proper degree of exhaustion will arrest this transmission, and any common air-pump can be made to prove that sound is with difficulty transmitted through a partial vacuum, and not at all when the vacuum is somewhat nearer to perfection. This experiment is acknowledged to be intended for a demonstration that the air molecules are the media for transmitting sound; that without such a medium there can be no sound, and that there exists no peculiar sonorous imponderable fluid which pervades the air, and should be the cause of sound transmission. When now we see that more highly rarefied air behaves toward electricity in exactly the same way as the lesser rarefied air behaves toward sound—namely, that at a certain degree of rarefaction the transmission becomes more imperfect, and at a certain point stops entirely—we are driven to the conclusion that electricity, as well as sound, is merely a peculiar form of motion of ponderable matter.

The conventional method of calling electricity a fluid must be understood to be only for the sake of convenience in explaining the phenomena presented. An argument in favour of this custom is that electric currents behave like water in two respects—namely, moving under greater or smaller pressure and in greater or smaller quantities.

What in water is called pressure or head is in electricity called E.M.F., and as hydraulic pressure can overcome great mechanical resistances, so E.M.F. overcomes great resistances.

It is measured by a standard unit, which is properly called after the illustrious Italian who first invented an apparatus which multiplied the small E.M.F. of a galvanic couple, the column of Volta. The quantity of electricity discharged through a channel is measured by another standard, also very appropriately named after the great French investigator Ampère, who discovered the laws governing the mutual action and reaction of current of great quantity.

That rarefied air is by no means so good a conductor as assumed by many is proved by the fact that it requires a considerable E.M.F. to pass it through. Machines producing static electricity, either by friction or induction, give that high E.M.F., while a single large galvanic cell, or, better still, a thermo-electric couple, offers the other extreme—viz., a large quantity of very low E.M.F., utterly incapable of being transmitted through any kind of vacuum.

I referred in the beginning of this paper to the application of the knowledge recently obtained in regard to the behaviour of electricity in rarefied air and in vacuo for the purpose of explaining certain natural phenomena. The phenomena are principally the aurora borealis and australis, and especially those which are related to the immense enigmas which from time to time appear in the heavens, the comets, which alarm the ignorant. On future occasion I hope to have the satisfaction to show you that all the peculiarities presented in both cases may be satisfactorily accounted for by the lately-discovered facts to which I have called your attention to-night.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts for the past week amounted to £4,164.

West Coast of America Telegraph Company.—A dividend of 6s. per share has been declared by the Directors of this Company for the current half-year, payable January 7.

Western and Brazilian Telegraph Company.—The traffic receipts for the past week, after deducting the fifth of the gross earnings payable to the London Platino-Brazilian Telegraph Company, were £3,464.

PROVISIONAL PATENTS, 1888.

December 21.

18,677. **An electric switch.** Lionel Beresford Bethell, Hill Farm, Morestead, near Winchester, Hampshire.

18,679. **A self-acting electric thermometer fire alarm, or temperature indicator, and atmospheric change indicator.** Lionel Beresford Bethell, Hill Farm, Morestead, near Winchester, Hampshire.

18,712. **Improvements in electric locks, bolts, and the like.** Charles Wells, 22, Southampton-buildings, Chancery-lane, W.C., Middlesex.

18,715. **Improvements in or connected with telephones, speaking tubes, stethoscopes, phonographs, and other instruments through which sound waves pass.** Frederick John Smith, 23, Southampton-buildings, Middlesex. (Complete specification.)

18,718. **An improvement in tubular posts for telegraphic and other purposes.** Carl Ernst Julius May, 28, Southampton-buildings, Chancery-lane, London, W.C.

December 22.

18,727. **Improvements in electrical continuous current transformers.** Robert Percy Sellon and Charles Watson, 112, Belvedere-road, Lambeth, Surrey.

18,747. **An arc lamp regulator for electric lighting.** Henri Alexandre Gigaroff, 2, Wood-street Square.

18,754. **Improvements in or relating to galvanic batteries.** George Cecil Dymond, 6, Lord-street, Liverpool. (Carl Gassner, Germany.)

18,763. **Improvements in apparatus for detecting the presence and direction of currents of electricity.** Charles Barnard Burdon, 3, Kimberley-street, Princes Park, Liverpool, Lancashire.

18,784. **Method of and means for regulating electric currents, dynamo machines, and electric motors.** Wilhelm Friedrich Lahmeyer, 433, Strand, London.

18,790. **Improved electrical signalling apparatus.** Sigmund Schuckert, 53, Chancery-lane.

December 24.

18,807. **Improvements in the method of and means for producing intermittent electric currents.** Thomas Parker 70, Market-street, Manchester.

18,812. **Improved method and apparatus for the distribution of electricity by means of alternating currents of electricity in conjunction with electrical storage.** Reginald Frederick Yorke, The Oaks, Haywards Heath, Sussex.

18,832. **An electric miners' safety hand lamp which may be used for domestic and other purposes.** Edward Thomas Boston, Elm View, Arundel-road, Weston-super-Mare, Somersetshire.

18,854. **Improvements in electrical switches.** Henry William Short, 53, Chancery-lane, London.

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18,856. **Improvements in printing telegraphs.** George Valentine Sheffield and Moses Lowenstein, 53, Chancery-lane, London.

18,858. **Improvements in electro-chemical generators.** Frederick John Brougham, 46, Lincoln's-inn-fields, London. (La Société Perreur-Lloyd and fils, France.)

DECEMBER 27.

18,881. **Improvements in the preparation of materials which have to be submitted either to voltaic heat or to electric heating, combined with electrolysis.** Louis Reuleaux, 46, Lincoln's-inn-fields, London.

18,900. **Improvements in electric telegraphy.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

18,908. **Improvements in electric arc lamps.** George Ben Goodfellow and Patrick James Charles, 70, Market-street, Manchester.

18,911. **An improvement in dynamo-electric machines.** Benjamin Hillier Antill and Edward Friedrich Hermann Heinrich Lauckert, 28, Southampton-buildings, Chancery-lane, London. W.C.

DECEMBER 28.

18,922. **Improvements in electrical switches.** Thomas Wardell, 87, St. Vincent-street, Glasgow.

18,930. **An electric automatic work detector and recorder.** Joseph Blamires and William Blamires, Phœnix Mills, Leeds-road, Huddersfield.

18,966. **Improvements in or connected with telegraphic transmitters.** Julius Timm, 77, Chancery-lane, London, W.C.

18,968. **Improvements in and relating to electric primers or igniters for blasting or firing mines, torpodoes, projectiles, guns, and the like.** Edmund Louis Zalinski and Henry Julius Smith, 77, Chancery-lane, London, W.C.

DECEMBER 29.

18,991. **A bent plate storage battery.** Matthew Doubleday, 81, Carrington-street Bridge, Nottingham, and Thomas William Bush, Willey Old Hall, Willey Park, Broseley, Shropshire.

18,994. **Improvements in and appertaining to the manufacture of metals or metallic alloys by means of electricity.** George Cecil Dymond, 6, Lord-street, Liverpool. (Jean Marie Anatole Gérard Léscuyer, France.)

DECEMBER 31.

19,034. **Improvements in secondary voltaic batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

19,045. **Improvements in magnet call bells.** Thomas John Handford, 50, Bedford-row, London, W.C. (The Western Electric Co., United States.)

19,049. **Improvements in electrical firing keys.** Frederik Vilhelm Andersen, 3, Elm-court, Temple, E.C.

19,058. **Improvements in electric batteries.** James Yate Johnson, 47, Lincoln's-inn-fields, Middlesex. (Fernand Gendron, France.)

19,061. **An improvement in materials to be used in galvanic batteries.** Alice Cornwell, 24, Southampton-buildings, London, W.C.

19,066. **A new or improved secondary clock.** James Grieve Lorrain, Norfolk House, Victoria Embankment, London, W.C.

19,067. **A new or improved secondary clock.** James Grieve Lorrain, Norfolk House, Victoria Embankment, London, W.C.

19,068. **A new or improved method of and apparatus for storing energy in small mechanical accumulators.** James Grieve Lorrain, Norfolk House, Victoria Embankment, London, W.C.

19,069. **A new or improved method of and apparatus for storing energy in small mechanical accumulators.** James Grieve Lorrain, Norfolk House, Victoria Embankment, London, W.C.

19,070. **Improvement in electric arc lights.** Charles Wells, 22, Southampton-buildings, Chancery-lane, W.C., Middlesex.

COMPLETE SPECIFICATIONS ACCEPTED.

DECEMBER 29, 1887.

17,902. **Improvements in apparatus for telephone exchanges.** Sydney Pitt, 24, Southampton-buildings, London, W.C. (Charles Ezra Scribner, United States.)

JANUARY 2, 1888.

56. **Improvements in the manufacture of the incandescing portion or luminant of incandescence electric lamps.** James Yate Johnson, 47, Lincoln's-inn-fields, Middlesex. (Theodore Mace, United States.)

JANUARY 12, 1888.

531. **Improvements in and means or apparatus for and connected with the generation, distribution, measurement, and control of electricity.** Henry Edmunds, 47, Lincoln's-inn-fields, London.

FEBRUARY 20, 1888.

2525. **Improvements in arc electric lamps.** Charles Richardson 46, Leopold-street, Weaste, near Manchester.

FEBRUARY 21, 1888.

2586. **Improvements in and relating to incandescent electric lamps.** Rankin Kennedy, 96, Buchanan-street, Glasgow.

FEBRUARY 23, 1888.

2698. **Improvements in the construction of sanitary and magnetic mattresses.** Edward Parker Dove, Sunbridge Chambers, Bradford, Yorkshire.

FEBRUARY 24, 1888.

2784. **A method of and apparatus for electrically lighting railway and other carriages.** John Imray, 28, Southampton-buildings, Chancery-lane, London, W.C. (Robert Imray, S. Australia.)

2785. **Improvements in holders for electric glow lamps.** Edward Frederick Hermann Heinrich Lauckert, 28, Southampton-buildings, Chancery-lane, London, W.C.

2794. **Improvements in electrical firing keys or contact makers.** Charles Ambrose McEvoy, The London Ordnance Works, Bear-lane, Southwark, Surrey.

FEBRUARY 29, 1888.

3071. **Improvements in miner's safety lamp.** John Pearson, 3, Quality-court, London.

JUNE 13, 1888.

8700. **Improvements in and relating to electric batteries.** Louis Marie Joseph Charles Clement Renard, 23, Southampton-buildings, London.

AUGUST 18, 1888.

11,941. **A new non-magnetic metallic alloy.** Heinrich Ostermann and Charles Lacroix, 68, Fleet-street, London. (Date applied for under Section 103 of the Patents, &c., Act, 1883, 25th April, 1888.)

NOVEMBER 14, 1888.

16,556. **Improvements in apparatus for adjusting the electric or other light in projecting lanterns.** Herbert Charles Newton, 6, Bream's-buildings, Chancery-lane.

SPECIFICATIONS PUBLISHED.

During the week ending 22nd December, 1888.

1887.

17,726. **Electromotors.** J. G. Statter. 6d.

1888.

1213. **Applying electricity to spectacle frames.** J. T. Leighton. 8d.

1383. **Electromotor or electric current meter.** F. Borel and E. Paccaud. 11d.

11,065. **Electric lamps.** W. P. Thompson. (Westinghouse.) 6d.

11,681. **Electric batteries.** C. E. Liebert and S. A. Rosenthal. 6d.

15,388. **Regulating dynamo-electric machines.** A. Shippey. (Waterhouse.) 8d.

15,612. **Insulators for electrical conductors.** J. C. Love. 8d.

During the week ending 29th December, 1888.

1887.

5880. **Weighing machines and dynamo meters.** (Reprint with alterations.) H. Knight. 2s. 4d.

17,138. **Generating and converting electric currents.** R. H. Courtenay. 8d.

17,415. **Electrical measuring and recording apparatus.** L. G Lorrain. 8d.

17,966. **Electric batteries, &c.** O. Y. Rhodes. 8d.

1888.

1875. **Dynamo-electric machines, &c.** G. Hookham and R. H. Housman. 8d.

1891. **Flexible battery cell, &c.** M. Bailey and J. Warner. 8d.

3312. **Voltaic batteries.** E. Tyer. 8d.

14,984. **Rotating hydro-extractors by electricity, &c.** R. R. Hutchinson. 8d.

16,146. **Electro-medical batteries.** F. Moreton. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	$4\frac{1}{4}$
12 Feb.	2/0	— fully paid	5	$5\frac{1}{4}$
14 Nov.	0/4½	Con Telephone & Main ...	1	$\frac{5}{8}$
27 July	10/0	India Rubber, G. P. & Tel.	10	$8\frac{1}{8}$
16 Mar.	5%	Maxim Weston	1	$\frac{1}{8}$
30 May	2½%	Oriental Telephone	11	$\frac{1}{2}$
26 April	4/0	Reuter's	8	$7\frac{1}{2}$
......	...	Swan United	$3\frac{1}{2}$	$2\frac{5}{8}$
12 July	12/0	Telegraph Construction ...	12	$40\frac{1}{2}$
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	14

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NOTES.

Meiringen.—The village of Meiringen, in the Bernese Oberland, is to be lighted entirely by electric light.

O.S.A. Paper.—Mr. Snell reads his paper on "Electro-motors" next Wednesday at the Central, at 7.45 p.m. Visitors may attend.

Metz.—The German Government have established extensive electric lighting plants for the barracks and fortifications, including search lights and portable plants.

Telegraph to China.—The arrival is announced at Warsaw of several French engineers who are to extend the telegraph line between Russia and China, *viâ* Siberia.

Reading.—It is expected that the electric light installation at Reading, now being completed by Messrs. Laing, Wharton, and Down, will be ready for lighting some of the streets in a few days.

Alternate Motors and Meters.—With reference to alternate motors Mr. Ferranti writes to us that he is not the owner of a motor; what he has bought is a Swiss meter, details of which may be published shortly.

The St. James' Station.—Work is rapidly progressing at the St. James' central station; two of the large boilers are already down, and other machinery is being added. The station will probably be ready for work in six weeks' time.

Royal Meteorological Society.—The annual general meeting will take place at 25, Great George-street, Westminster, on Wednesday next at 7.15 p.m., when the president, Dr. W. Marcet, F.R.S., will deliver his address on "Fogs," illustrated by lantern slides.

Birmingham.—The Birmingham Council are understood to be considering whether they shall not themselves apply for powers to light the town, instead of allowing the concession to go to a private firm, and so reduce the profits of the gas department, which in that town is owned by the municipality.

France.—Montluçon (Allier) has a central station with 400 lamps. Valleraugе (Gard) will shortly have a central station for 500 lamps, supplied from a turbine half a mile away. The town contains important silk spinning mills, and these will be supplied night and day, besides 25 lamps for the public streets.

Writing on Rose Leaves.—The passage of a current of electricity through a rose leaf is found to take out the colour, leaving a white mark. This effect has been prettily used at a fashionable dinner, where the lady of the house had the place of each guest indicated by a rose, on the petals of which the name was thus delicately inscribed.

Berlin.—Besides the two large central stations in Berlin, the third, which is now to be established, brings the total up to a supply of 200,000 lamps, requiring 18,000 h.p., representing about one quarter of the total number of gas jets in Berlin. Steam-engines of 1,000 h.p. will be employed, instead of those of 380 h.p. as hitherto installed, for facility of supervision.

Electrical Steam Explosive.—Mr. Samuel Joyce, jun., of Richmond-road, Dalston, proposes to use a new form of blast for mining, in which the explosive force of steam is utilised. The steam is generated from water enclosed in an air-tight compartment by a wire heated by the passage of an electric current. The contacts are enclosed in an air-tight box.

Geneva.—*L'Electricité* for December 29 contains descriptions and illustrations of the plant in use at the Geneva lighting station, consisting of Picard turbines coupled direct to Thury dynamos. The mains are underground, laid by Messrs. Siemens and Halske, and plans of the district are given, together with details of the switchboards used at the installation.

Electric Boxes.—The Electric Automatic Delivery Box Company has been reorganised, and is expected at last to make electric boxes. A small amount of £20,000 has been knocked off the price of payment to vendors of the patents, but even for £10,000 *we* should like an order for electric boxes, and would make any amount of them at a price allowing "20 per cent. profit."

Lectures on the Calculus.—A special course of twelve lectures, with exercise work, will be given by Prof. Perry, F.R.S., at the Finsbury Technical College, on the differential calculus. The course will be arranged to give a working knowledge of the subject to electrical and mechanical engineers who have only an elementary knowledge of algebra and trigonometry. The first lecture will be given on the 15th inst.

Anti-Friction Packings.—We have received from Messrs. D. G. Cresswell and Son, of Barkerend-road, Bradford, their catalogue of anti-friction packing for engines—a packing needing no oil or tallow, and very lasting in its qualities. They also manufacture various asbestos compounds, sheeting, joints, washers, and cloth, with an asbestos anti-corrosive cement for use for making steam joints on pipes and boilers.

Electrical Warfare.—Frank R. Stockton, author of "The Lady or the Tiger," is writing a romance in the American *Once a Week*, setting forth a supposed war between England and the United States, in which the American Government adopt the idea of letting out the contract to a war syndicate who construct all sorts of electric engines, torpedoes, signals *et hoc genus omnes*, and speedily knock the mother country into fits.

Annual Supper.—On the last Saturday of the old year the annual supper of Messrs. Laing, Wharton, and Down's employés took place at the Queen's Arms Hotel, Queen-street, E.C. Mr. D. C. Bate, the firm's engineer, took the chair, and after ample justice had been done to the excellent catering of the landlord, the usual loyal and patriotic toasts honoured, and continued success to the firm drunk with three times three and one cheer more, a most enjoyable evening was brought to a close by some excellent song-singing, to the accompaniment of a piano presided over by Mr. J. Sugden, a member of Messrs. Laing Wharton, and Down's staff.

Armstrong's Lock Nuts.—The Walsall Electrical Company manufacture a new lock nut (Armstrong's patent) suitable for shafting, gearing, foundations, etc., and other places where nuts may work loose from vibration. The top of the bolt is octagonal, slightly smaller than the screw; when the nut is screwed up, a cup fitting this octagonal part is slipped over and fits on top of the nut in any position from an eighth of a turn. A split pin keeps this in position, and of course effectually prevents the nut from turning or getting loose, and also acts as a protective cap against rusting or corrosion. When the cap is applied the

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whole is as rigid as a rivet, and neither threads, bolt, or nut are disturbed or injured.

Transmission of Power.—One of the largest plants in the United Kingdom for transmission of power by electricity is likely soon to be practically carried out. This is for a large paper mill, situated near a river where a fall of water estimated to give a theoretic value of some 700 h.p. is available. Experiments are now being undertaken to determine what is the actual force, and a thousand pounds or so is being expended on sluice-gates for this purpose. The contract—which is arranged subject to the result of these tests—will stipulate that not less than half the theoretic value, including all losses, will be delivered at the further end, a distance of 3½ miles, so that at least 350 h.p. will be transmitted. Every engineer, electrical or otherwise, will be interested in the result of this undertaking.

City Lighting.—On Tuesday, at the meeting of the City Commission of Sewers, the chairman, Mr. W. H. Pannell, replying to Mr. Thompson, said the question of inviting tenders for the supply of the electric light to the City was still before the engineer, the solicitor, and Mr. W. H. Preece, F.R.S., who were framing the conditions under which tenders should be asked. He hoped their report would be before the committee at their next meeting, but until the arrangements were finally completed, no tenders would be invited. Mr. Baylis, the solicitor, in answer to Mr. Rose-Innes, said it would be usual, in the event of any applications by companies for provisional orders to light the city by electricity, for the Commission of Sewers to oppose them in order formally to obtain a *locus standi* when the schemes came before the Parliamentary Committee.

Electrical Architects.—A writer in the *Builder* suggests that, in view of the probability of great extension of electric lighting in the immediate future, instruction in the principles of the use of electricity should be given by the Royal Institute of British Architects and the Architectural Association. The editor "quite agrees that practical electricity is a subject which the architect of the future will have to study, and that it ought to form part of an architectural student's curriculum." A subscription to a technical paper, a visit to one or two good electric light installations, and a few conversations with a practical electrical engineer would be useful, in this present time, to a great many practising architects, who will shortly have to deal with the problems of electricity, specially of electric light, but also, in all probability, in many other domestic electric applications in modern houses.

Protest at St. James's.—A meeting of the residents of Pall-mall and St. James's-square, held at Willis's Rooms the other day, passed the following resolution: "That this meeting is of opinion that the installation and erection of a central station for electric lighting for the parish in the immediate neighbourhood of Pall-mall and St. James's-square is calculated to injure the commercial and residential value of property in the neighbourhood, and is quite unnecessary in view of facilities for bringing the current from distant localities more suited for the purpose." Mr. Foster, who stated that he was interested in the St. James's Electric Lighting Company, opposed the motion, contending that the works would be a boon to the neighbourhood. Mr. J. T. Musgrave also thought that the electric works would not create any nuisance, as smokeless coal was to be consumed, and the company would consume their own smoke. The resolution was carried by 19 to 11.

Electric Engraving Pen.—We have been shown an ingenious pen for use by engravers, invented by Mr. Boyle, in which the engraving is done by electricity instead of by a graver or by acid. The action is practically to cause a series of small arcs to burn away the metal to a greater or less depth as desired, to form an engraved plate. An armature capable of very rapid vibrations is mounted in the form of a pen, and has a rod with a platinum tip connected to it, projecting slightly through a glass point. One wire from a battery is connected to the plate which is to be engraved, and the other to the terminal of the pen. On touching the plate and tracing out a design, or lettering, the platinum point vibrates up and down, and the small arcs which form at the point of contact burn away the metal and engrave the plate to a greater or less depth according to the quickness of motion. The plate thus engraved can be used at once for printing. We understand a large number of pens have been ordered by engravers and others. The sole right of manufacture has been assigned to the Electrical Apparatus Company, of 4, Charing Cross.

Journal of the Old Students' Association.—The *Journal* of the City Guilds Old Students' Association assumes a new phase, and will be devoted to the interests of past and present students of the Finsbury and Central Institutes. It is at present intended to publish six numbers per session, and to commence and end the *Journal* volume with the annual session of the colleges. While the *Journal* will naturally be chiefly concerned with scientific and literary matters, more prominence than hitherto will be given to the social aspects of college and O.S.A. life. The committee appeal to every student, past and present, to give all the assistance possible, either by becoming subscribers, or by sending or procuring contributions for publication. Several old students who have received appointments in the provinces and abroad have promised to send accounts of their travels and experiences, and these, no doubt, will form an interesting feature of the new volume. A register of situations wanted is kept in conjunction with the O.S.A.; communications about these should be addressed to the president of Old Students Association, Mr. Thomas Adams, 25, Maitland-park-road, N.W.

Derby Central Station.—The nucleus of a central electric light station is being put down at Derby by Messrs. John Davis and Son, of All Saints' Works. The plant, in the first instance, is for 500 10 c.p. lamps, and will comprise accumulators which will ensure a steady supply. The current will be on till 9 p.m., or later by special arrangement, and the charges are on the basis either of from dusk to eight, or from dusk to nine, on a sliding scale according to the candle-power, as follows:

	Incandescent Lamps.	
C.p.	Dusk to 8 p.m.	Dusk to 9 p.m.
10	£1 5 0	£1 15 0
20	2 0 0	2 15 0
32	3 10 0	5 0 0
150	8 10 0	11 10 0
200	10 10 0	14 10 0
300	12 10 0	16 0 0
500	20 0 0	30 0 0
	Arc Lamps.	
400—500	14 14 0	18 18 0
1,000	18 0 0	24 0 0
1,500	25 0 0	35 0 0

These prices include carbons and attendance for arc lamps.

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The current will be supplied through the day in foggy weather when light is necessary, but not on Sundays. A guaranteed minimum rental of £5 per annum is required.

Polar Investigation.—The report of the Norwegian party of the International Polar Investigation, says *Nature*, contains the results of the observations which were made according to the programme decided upon at the Polar Conference at St. Petersburg, in August, 1881. The observations were made at Bossekop, in Alten, in lat. 69deg. 58min. N. and long. 23deg. 15min. E. of Greenwich. The first volume, issued in 1887, contains the astronomical and meteorological observations, and the second volume (Christiania, 1888) gives the results of the magnetic determinations and observations of auroræ. In the meteorological section, tables are given of the hourly readings of the temperature and humidity of the air, height of barometer, direction of winds and nature of clouds, extending from August, 1882, to August, 1883, inclusive, and concluding with monthly averages. In vol. ii. are given the records of the determinations of the magnetic declination and horizontal and vertical intensity. These were made fortnightly during the year, at intervals of five minutes during the day, so that the carefully-executed curves expressing the results of the observations are very detailed and convenient for comparison with the complete descriptions of auroral displays, the records of which are also contained in this volume. No doubt these results will be of great service in correlating auroræ with magnetic disturbances.

Telephone Extension.—A writer in the *Western Morning News* mention a method to persuade people who know nothing about telephones to join. In the United States, especially out West, they adopt the plan of fixing an electric bell for five dollars a year in the house of anyone who thinks he should like a telephone, but is not sure about it; and then when the bell rings the man puts on his hat and walks down to the office, and talks to the person who has rung him up, paying five or ten cents for the talk. In a few weeks the man finds it such a nuisance to have to walk to the office every time, that he calls upon the company to fix him up a telephone, and so becomes a subscriber. Most of the storekeepers in Dixon, 90 miles from San Francisco, where an exchange has just been opened, have only a bell and no telephone; but they can at any time, by walking down to the office, talk to San Francisco, or Sacramento, or any other town in California, and any person in these towns can ask the agent at Dixon to ring up any of the Dixon subscribers. The writer suggests that if any town or village within 50 miles of the nearest large town had a wire connecting it therewith, and a few electric bells to begin with, to the principal residents or shopkeepers, the value of the telephone would be better appreciated. In England the telephone is regarded as a luxury; in America it is deemed a necessity. The suggestion is worthy of consideration by the telephone companies desiring further subscribers.

Electricity v. Gas.—The gas journals are at last beginning to wake up. The annual review has come round, and things are not quite so bright as they could wish. There is a big struggle in front of them, and the sooner they know and acknowledge it the better. Says the *Gas and Water Review:* "We should like to be able to chronicle a greater increase in the sale of gas, but it is no good blinking the matter. If it were not for the application of gas to heating and cooking purposes, and to its rapid advance as a motive power, the suppliers would have a poor result to show. It is a fact not to be denied that the electric light is steadily gaining ground, and we regret that contemporary journals should be so blind to the interests of the great industry whose welfare they are supposed to watch, as to throw ridicule upon the advances of electric lighting. It is mainly due to the want of forethought of the conductors of the *Gas Journal*, and those associated with them, that gas suppliers opposed the Electric Lighting Bill in 1882; they should have endeavoured to have secured powers for gas companies to supply electric lighting, as is now being done largely throughout the United States of America. It is certain that Parliament will not now grant such powers to gas suppliers, and they must extend their efforts in other directions. Let them canvass their districts, and induce consumers to heat by gas, cook by gas, and have gas-engines fixed wherever power is needed. The time has most assuredly passed by when gas consumers will come cap in hand to the gas companies, and then have to accept their irksome and arbitrary regulations. It is not sufficient that gas is cheap; the business must be sought for, or others will secure it."

Electric Sugar Swindle.—On Friday the sweet hopes of the electric sugar investors were ruthlessly dashed by receipt of a telegram mentioning "Grave doubts developed, process not what claimed, doubts fully confirmed, obtained access to upper floor, satisfied the sugar manipulated from refined." The shares fell at once from £117 to 25s. The wonder is that the grave doubts were not sufficiently developed before; the fact that the denial of access to the upper floor was so long complied with, and the belief in the process by those unacquainted with electrical science so fervid, is another instance of the gullibility of the public. This belief was fully shared by several financial papers, and the "Electric Sugar Bubble" will probably rank in financial history amongst the most notorious swindles of the time. Dr. Silvanus P. Thompson writes to the *Times* as follows: "Sir,—In October last you did me the favour of inserting a letter in which I sounded a warning note to the too-confiding investor, pointing out that so far not one shred of proof had been forthcoming that electricity had anything whatever to do with the so-called process for the 'electric' refining of sugar. Nor was I alone in my disclaimer; for in all the technical electrical journals similar warnings as to the true nature of this alleged process were given in guarded, but unmistakable terms. Unfortunately, it would seem that would-be investors prefer the opinions of every other sort of adviser to that of those persons who have made the study of electricity and its powers their life-long pursuit. The result is that whereas a week ago they were clamouring for the privilege of buying up the shares at 300 per cent. premium, they now learn on unmistakable authority from your Philadelphia correspondent that the whole thing was a shameless swindle. They now know that the name 'electric was a mere cover for a vulgar cheat, in which previously refined and crystalised sugar was surreptitiously conveyed to the factory and substituted, behind locked doors, for the unrefined article. This is not the first swindle in which the word 'electric' has been skilfully used by the knave to dupe the fool; nor, I fear, will it be the last." The latest telegrams state: "Warrants issued, parties fled to Canada."

Thomson-Houston Catalogue.—An advance copy has reached us of what is a really handsome, complete, and

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tasteful catalogue, to be issued by Messrs. Laing, Wharton, and Down, of the Thomson-Houston Company's electric apparatus. It is a catalogue such as we do not often see got up by English firms (although we could no doubt produce them if the price were paid), and it very forcibly illustrates the progress of the Thomson-Houston system in the last few years. We see first a small country factory, as in 1882, and a gigantic concern at Lynn, Massachusetts, as in 1888, consisting of six large and handsome blocks of buildings, all of which are as busy as possibly they can be in turning out arc and incandescent dynamos and Thomson-Houston motors. A further building is shown—the carbon factory—where specially tested carbons are made for the various supply companies. In the catalogue, beautifully engraved and delicately printed cuts show the arc lamps, of all types, for houses, streets, projectors for posts and wall brackets, and incandescent lamps for long distance series lighting, with incandescent dynamos. The T.H. compensator system is used for greater distances than 2,000ft.; this is not a transformer, but a simple arrangement of coils to maintain perfect regulation of the current which may occur at the distributing centre. The Thomson-Houston transformer system is illustrated, with alternating dynamos and exciters, either together or separately run, with transformers, waterproof in construction, cased in, and capable of being hung outside in any convenient position. The Thomson-Houston motor comes in for a fair share of attention. Some idea of the extent of the growth of the system may be gathered from the figures given at the end of this catalogue, which show that up to the 1st January, 1889, 435 arc light companies have been established, supplying some 52,000 arc lights in America; and 175 incandescent companies, supplying 97,000 incandescent lamps. Plans of various Thomson-Houston stations are given, of from 100 to 1,000 h.p., and altogether the issue of the catalogue is one of the best illustrations of the enterprise of the promoters of this system that could be seen.

Woodhouse and Rawson Catalogue.—The new Woodhouse and Rawson, Limited, catalogue, compiled by Mr. Rentell, has just been issued. It is a neat and handy book of some 200 pages, describing almost every electrical requisite conceivably required for electrical contractors, ranging over the list of engines, dynamos, lamps, and all and sundry fittings, with other materials necessary to the working of electric installations and other electric applications. The scheme of the company has been to place themselves in a position of central supply, so that even where they do not manufacture themselves, special terms are arranged with other makers, so that a customer can obtain on equally good terms all they require without opening new accounts. A number of tables, with other interesting information, are given, and the perusal and study of the catalogue will give a very fair idea of the present state of electrical industry. With reference to their own manufactures, the incandescent lamps may be specially mentioned. For some time the Woodhouse and Rawson Company have been busy supplying "unflashed" lamps, before-times stopped from legal difficulties. In their new catalogue these lamps find an important place. An entirely new type of carbon has been produced, of such a hard and dense nature that good filaments are made without flashing, and, of course, are thus homogeneous in substance throughout. Special attention is paid to marking the voltage of lamps, so that, whether of greater or less candle-power, the brilliancy or degree of incandescence shall be the same in all lamps. The charges in the filament have enabled shorter filaments to be used, thus better resisting breakage from vibration. Messrs. Woodhouse and Rawson have settled their normal efficiency of lamps at 3·5 watts per candle-power, with an average life of over a 1,000 hours, comparing favourably with other makers, and where it is more economical to run higher lamps, are marked at an efficiency of 2·75 watts per candle, with a slightly increased cost for renewals. Special attention is given to lamps for primary battery lighting. Their noted hair filament lamps for surgical and dental purposes, theatrical effects, electric jewellery are constructed for extra high efficiency for small lamps. A speciality is made of silvered lamps. Standard lamps for ordinary use are made of 8, 10, 16, 20, 50, and 100 c.p. A large number of testimonials from private and public individuals, and from various publications, are given to testify to the excellence and efficiency of the Woodhouse and Rawson lamps.

Standards of Light.—The *Journal* of the Society of Arts for 21st December contains a paper on "Standards of Light," read by Mr. W. J. Dibdin, F.C.S., in which he sets forth the variations and vagaries of standard candles, and incidentally mentions, in regard to manner of burning standard candles, that in the Gas Works' Clauses Acts, 1871, it is specifically laid down that "the tip of the wicks shall be glowing and slightly bent," and thus a distinct condition is introduced. Mr. Dibdin recommends a modified form of the "ten candle test," which he has called the "Pentane Argand," as a most reliable standard, free from all objection from the "height of the flame" point of view, independent of coal-gas and atmospheric influences, such as temperature or pressure; possessed of the advantage of being a decimal factor—viz., ten candles; and furthermore being a desirable unit to use in coal-gas testing during foggy weather, as the distance of the opposing lights from the photometer disc is for that purpose practically equal. The arrangement possessed of these advantages is very simple, no meter, governor, or other measuring or controlling adjunct, beyond a simple tap, being necessary. It is merely a small argand burner suited for burning gas-air. Supported 2·3in. above the steatite burner is a screen to cut off the light emitted from the top of the flame, and indicating rods to assist in regulating the flame to a height of three inches. The standard combustible is the vapour of pentane; this is driven forward to the burner by a current of air from a holder or pressure bag, as may be convenient, about half a cubic foot of air per hour being required. The pentane is contained in a carburetter precisely similar to that of Mr. Methven's, and the air carburetted with the pentane in the same way that he carburetts the coal-gas for his later form of standard. A variation in the temperature of the carburetter makes no difference, as the same result is obtained when the trough of the carburetter is filled with water at 90deg. F., and then with ice and water. The flame should be adjusted to a height of 3in. for uniformity, but if from accident the flame falls to two and a half inches or rises to over four inches, no difference is observable in the volume of light emitted under the screen. This remarkable result is ascribed to a compensating action in the blue portion of the flame, which is reduced in size when the luminous portion is lowered, and contracted in bulk, and thus causes a greater length of the white flame to be seen under the screen, and

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inversely, when the flame is raised and expanded in width, the blue portion is also increased, and thus compensates for the otherwise greater intensity of the white portion. Mr. Dibdin hopes that it may form a neutral ground on which, for a time at least, conflicting interests may meet to their mutual advantage.

Proposed Electrical and Industrial Exhibition. A syndicate of commercial gentlemen in Birmingham, says the *Birmingham Daily Post*, are taking active steps to promote an electrical and industrial exhibition on a very extensive scale in Bingley Hall during the months of August, September, and October next. Private circulars have been sent to a large number of traders and others likely to be interested in such a movement, and the result so far has been of a satisfactory character. A long and influential list of patrons—gentlemen well known in scientific, commercial, and social circles—has been secured, and the names of some eminent firms are mentioned as being likely to send exhibits. These will be divided into two portions—electrical and industrial. The former, according to the prospectus of the promoters, is to include a "complete display of electric lighting, with arc and incandescent lamps, upon every known system and combination, working in series, in parallel, direct and through transformers of various types; lamps of from one to 25,000 c.p.; all systems for electric transmission of power, electrical motive power to be used for all working exhibits, electric motors on all systems, electric energy applied to all possible industrial purposes, electric welding, electric smelting, electrotyping, deposition, telpherage working, etc., etc.; electric lighting and motive power for coal mines, with a model coal mine in actual work; electric telegraphy, signalling, telephones, bells, clocks, instruments, etc.; electricity as applied to medical and surgical purposes, and to marine engineering; exhibits of dynamos, battery appliances, instruments, and all novelties in electrical engineering; steam, gas, petroleum, and other engines." It will be seen from this epitome of exhibits that the electrical portion alone offers plenty of scope for a very interesting and attractive display. The coal mine is to be built of coal and to be worked by colliers. Birmingham trades, it is hoped, will be well represented in the industrial department, where stalls are to be set apart for manufacturers of pens, watches, bicycles, nails and rivets, screws and bolts, gas and electrical fittings, jewellery, machinery for electroplating, chemical trades, opticians, and any other industry or any speciality that may be desired. Of course, the public will be admitted on payment, and in the case of any profits being realised from the enterprise they will be divided between the General, the Queen's, and the Jaffray Hospitals. A guarantee fund has been set apart to meet any loss in the event of a deficiency, which is looked upon as very improbable on account of the attractions that will be offered. At the present time many of the details are not decided upon, but steps will be taken to popularise the exhibition by bands and other forms of entertainment; and it is stated that an attempt will be made to induce his Royal Highness the Prince of Wales to perform the opening ceremony.

The Cowles Process.—At the last meeting of the Cleveland Institution of Engineers, at Middlesbrough, a paper was read by Mr. William Boby, of London, on the Cowles process of production of aluminium, showing the value of the addition of small quantities of aluminium to iron and steel in the course of manufacture. After describing the Cowles furnace at Milton, which has already been fully described in this paper, Mr. Boby said that the greatest field of usefulness for aluminium was for mixture with cast steel. When the amount of concentration exceeded a certain amount the alloy became non-magnetic, and this was a property which might possibly be found to be of practical value. Another good property of aluminium, as produced by the process, was the quality of equal diffusion. A ladleful of molten steel would be impregnated with a minute proportion of aluminium if a small quantity of the broken-up alloy were placed in the bottom of it before the steel were poured in. The use of ferro-aluminium, said Mr. Boby, had not, up to the present, obtained any large dimensions in this country, but in the United States it was already largely employed. The effect of the alloy upon steel was to raise its elastic limit and ultimate strength, while it lowered its melting point, and facilitated the making of sound castings, the last-named point being one of great importance. This alloy was employed by the makers of "Mitis" castings in America, who obtained it from the Cowles Company, at Lockport. Mr. Boby's partner, when spending a few days there some months back, saw an order come in for 10 tons, and when it was borne in mind that one-tenth of one per cent. of aluminium was an ordinary proportion to add to steel castings it would be seen that this represented operations of some magnitude. The effect of ferro-aluminium upon puddled bar iron had been investigated by a member of the firm of P. and W. Maclellan, Glasgow, with most satisfactory results, the tensile strength being raised to 31 tons with 22 per cent. elongation, while the quality was equal to that of the finest mild steel. Mr. W. J. Keep, of the Michigan Stove Company, U.S.A., one of the largest stove-making concerns in the States, bore testimony to remarkably beneficial effects of ferro-aluminium as applied to cast-iron. English firms were commencing to use this alloy, and no doubt its employment would rapidly extend. Some of the best-known steelfounders were using it in England. With aluminium-bronze the breaking strain had been raised to 50 tons per square inch, and even with a test bar to nearly 60 tons. Aluminium-brass possessed, perhaps, the most surprising qualities of any of these alloys. To the ordinary constituents of brass 3½ per cent. addition of aluminium produced the astonishing result of 95,000lb. tensile strength, with a transverse strength of 72cwt. on a bar 1in. square and 12in. between supports. Both the bronze and the brass were unaffected by salt water, and promised to be extensively useful for many parts of machinery. In reply to questions as to other productions, practical details, and as to whether the Cowles Company had tried the electric welding, Mr. Boby said some small quantities of silicon-bronze had been made, but they had not pushed the sale, as the furnaces were fully occupied otherwise. Silicon-bronze was, however, used in the States for telephone wires, and was extremely strong. The Cowles Company had never produced pure aluminium in this furnace commercially. They say they could make it if the market required it. He could not say how the carbons were produced, but each lasted three days of 24 hours each. Electric welding had not been tried by the Cowles Company in this country. Mr. Wood, in proposing thanks, remarked that he had been told of orders for aluminium alloy from 50 different places in the neighbourhood of Cleveland recently, which went to show that the use was rapidly extending in this country.

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THE TELEPHONE IN THE WEST OF ENGLAND AND SOUTH WALES.

It is as well that Nature's law "like father like son" does not always hold good in matters commercial, else would the history of telephonic enterprise in this country prove very indifferent reading. As it is, we have not much to be proud of when we compare ourselves with other nations, and what little progress has been made in the adoption of the telephone must be sought for principally in the minor cities of these islands.

History of the Western Counties Company.

A very lively and promising offshoot of the United Telephone Company has its headquarters at Bristol, and as we recently had the opportunity of paying a visit to its central exchange, we propose to give a sketch of the rise and progress of the "Western Counties and South Wales Telephone Company, Limited." This company was registered in December, 1884, with a capital of £400,000, of which £100,000 was in preference shares, 20,000 of £5 each, bearing a cumulative dividend of 6 per cent., and 300,000 fully-paid ordinary shares of £1 each. The district within which this company is licensed to work by the United Company and the Postmaster-General is an extensive one, and comprises the counties of Cornwall, Devon, Somerset, Dorset, Hants (including the Isle of Wight), Wilts, Gloucester, Hereford, Monmouth, Glamorgan, Carmarthen, Pembroke, Cardigan, Brecknock, Radnor, all such parts of Salop, Worcester, and Warwick as are not included in a 20 mile radius from the General Post Offices at Birmingham and Wolverhampton respectively, and the Channel Islands. The district is clearly shown in the accompanying map Although the Western Company was not registered until December, 1884, the district was partially worked by the United Company as far back as December, 1879, by an exchange being opened at Bristol with 25 subscribers. The number now is 429 exchange and 82 private line, or a total of 511 renters. Clifton and Bristol are connected by trunk wires, with a switchroom at each place. Portishead Docks, 12 miles distant, and Avonmouth Docks, nine miles distant, are also connected with the Bristol exchange system. We think it worthy of notice that during the year ending 31st December, 1887, there were 625,631 calls to the Bristol Exchange, which, allowing a reply to each call, represents 1,251,262 communications. The year 1888 shows an increase over 1887 of 89,931 calls, or 179,862 communications; the 1888 total being 1,431,124.

An exchange was opened at Plymouth by the United Company in June, 1881, and trunk lines run connecting Devonport, Stoke, and Mutley, three towns which are practically one and the same. The company opened here without a license from the Postmaster-General for the purpose of testing the legality of their action. At this time there was a small exchange in Plymouth, which had about 20 subscribers, and was conducted by Messrs. Cox and Williamson, who were using instruments (microphone transmitter and Ader receiver) which were on July 25, 1882, decided by the courts to be infringements of the United Company's patents. This firm, however, were working under a Post Office license. Messrs. Cox and Williamson's business, exclusive of the instruments, was taken over by the Post Office, who gave notice to the United Company that not having a license they must close their exchange, they having at that time about 65 subscribers connected. The company then applied for a license, but it was refused, and the exchange was closed and remained so for some time. However, in spite of this, the Post Office never managed to obtain a larger number of subscribers to their system than 43. In February, 1885, the Western Counties Company having succeeded in obtaining a license from the Post Office reopened the old exchange of the United Company. When it came to a matter of competition, the Post Office had to give in, their subscribers gradually leaving them and going over to the company, and at length, in June, 1888, the official exchange was finally closed, while the company has now 251 subscribers.

This is briefly the history of the opening of the pioneer stations of the present extensive system worked by the Western Counties Company, and with this history the name of Mr. H. F. Lewis, formerly manager in the West of England for the United Company, now general manager and secretary of the Western Company, is most intimately connected. The following table A will give at a glance the history of the company's exchanges from their opening to the 31st December, 1888, with the number of subscribers to each:

Table A.

Name of town.	Date of opening.	No. of exchange subscribers.	No. of private lines.	Totals.
Bristol	March, 1879	429	82	511
Bath	Oct., 1886	53	28	81
Gloucester	June, 1887	40	23	63
Newport (Mon.)*	Jan., 1886	76	23	99
Cardiff*	Dec., 1885	117	49	166
Pontypridd	June, 1888	12	14	26
Swansea†	1887	137	27	164
Shrewsbury	June, 1887	29	25	54
Plymouth*‡	Feb., 1885	251	62	313
Torquay	Oct., 1885	151	26	177
Exeter*	June, 1887	38	33	71
Portsmouth	July, 1885	166	68	234
Bournemouth	Nov., 1886	188	23	211
Poole	Nov., 1886	14	1	15
Southampton	June, 1886	93	19	112
Weymouth	June, 1887	20	14	34
Jersey	Nov., 1887	26	—	26
Cheltenham	Dec., 1888	20	16	36
Worcester	Dec., 1888	6	15	21

* Opened in face of Post Office competition.

† The Western Counties Company bought up the original Swansea Telephone Company, which had been in existence since 1881.

‡ As we have explained above, this was originally opened by the United Company in 1881 and reopened by the Western Company in February, 1885.

Early in the present year the company expect to have exchanges open and in working order at Gosport, Tavistock, Dartmouth, Brixham, and other places. In the above table we have indicated the towns in which the company encountered Post Office competition by an asterisk. We may add, further, that at Newport the highest number of subscribers to the Post Office system was 44. It is now 35; the company having 68. In Cardiff the Post Office obtained 48 subscribers at one time, but have now only 33, as compared with the company's 117. Plymouth we have already spoken of. At Exeter, the Post Office have had an exchange since the year 1883, but never succeeded in obtaining more than a dozen subscribers—at least, so we were told—and have now closed their offices. The company, as will be seen, have in 18 months or so obtained 38 subscribers.

In the map, the existing exchanges of the company will be found marked black, those proposed to be or actually in course of being opened are lightly shaded

We will now give some account of the

Trunk Lines,

of which the company have an extensive system in work, and a still larger system in course of construction and proposed. Referring to the map again, a thick black line indicates lines completed, a thin and dotted line those in course of construction, and a dotted line those in the proposed stage. Starting from Bristol as the centre of the district, we find it connected by trunk lines with Bath, Portishead, Avonmouth, Sharpness Docks, and Gloucester. From Sharpness a line runs by a cable across the Severn, to Newport and Cardiff, from which places a loop includes the towns of Pontypool, Tredegar, Merthyr, Aberdare, and Pontypridd. From Cardiff, again, it runs to Briton Ferry and Swansea, where another loop includes the towns of Morriston and Landore. From Swansea the line runs to Llanelly, which is at present its farthest limit, though, as will be seen from the map, it is proposed to carry it on to the important town and docks of Milford.

Another group of trunk lines will be found centreing round Torquay, which is connected with Newton Abbot, Paignton, and Totnes. From this town a line, which is nearly completed, runs to Plymouth, and thence to Horrabridge and Tavistock. Eventually, this district will have lines running as far south-west as Falmouth and Camborne, and northwards to Bristol. The small trunk connecting Poole and Bournemouth is being extended to Southampton and Winchester, returning south again to Portsmouth and

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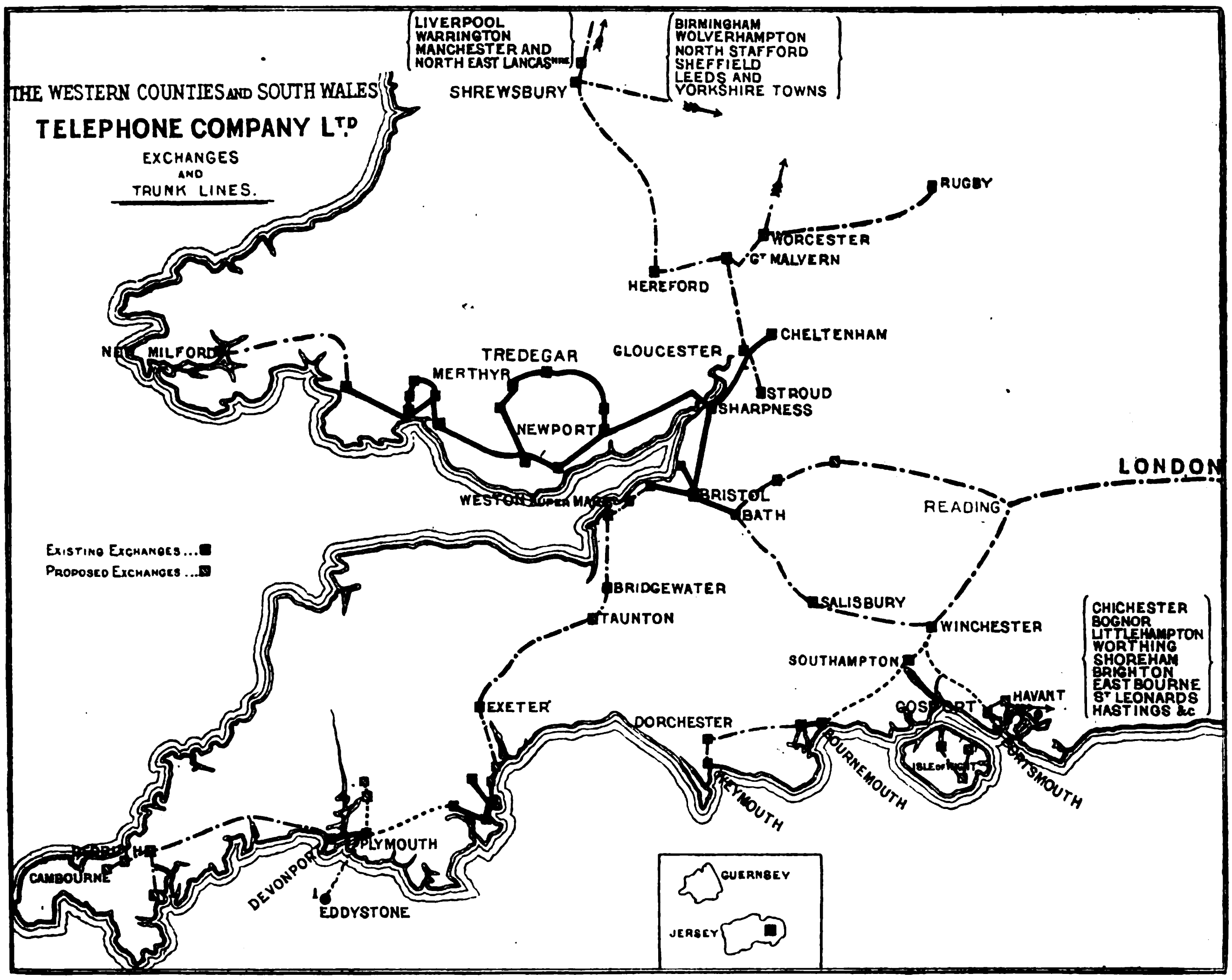

Lines Completed ▬▬▬ Lines Proposed — · — · — · Lines in Course of Construction · · · · ·

The above Map is intended to indicate the towns telephonically supplied and proposed to be supplied, though the names of many important towns are omitted. Thus in the South Wales District—Llanelly, Swansea, Briton Ferry, Pontypridd, Cardiff, Pontypool, etc., are indicated but without names, as are Tavistock, Totness, Newton, Brixham, and Torquay, in the Devon District.

Gosport. Gloucester also will soon have a trunk line to Cheltenham, where an exchange has just been opened.

The following table B gives the route and wire mileage of the existing trunk lines between the various towns:

TABLE B.

Names of towns.	Route mileage.	Wire mileage.
Bristol—Bath	14	56
Bristol—Avonmouth	9	36
Bristol—Portishead	11	33
Bournemouth—Poole	6	36
Bristol—Sharpness	21	210
Sharpness—Newport	31	189
Sharpness—Gloucester	18	72
Newport—Cardiff	14	196
Cardiff—Swansea	50	264
Swansea—Llanelly	12	48
Interlocal group, Swansea, Briton Ferry, Morriston, and Landore	12	66
Newport—Pontypool	11	22
Pontypool—Tredegar and Merthyr	22	44
Merthyr and Aberdare—Pontypridd	15	60
Torquay—Paignton, Totnes, and Newton Abbot	15	18
Plymouth—Plympton	5	5

From this table it will be seen that the company have trunk wires in operation to the extent of 266 miles of route and 1,355 miles of wire. The same figures with regard to trunk lines in course of construction which are expected to be opened for use at no distant date, read as follows:

Name of town.	Route mileage.	Wire mileage.
Gloucester to Cheltenham	9	18
Bournemouth to Southampton, Winchester, Portsmouth, and Gosport	72	144
Cardiff to Barry	10	20
Torquay to Plymouth	33	66
Torquay to Brixham	8	8
Torquay to Dartmouth	11	11
Plymouth to Tavistock	12	12

or a total of 155 miles of route and 279 miles of wire. The total number of poles required for lines constructed and in course of construction has been 10,500. The longest distance spoken over at present is from Bath to Llanelly, 140½ miles. This circuit includes a cable across the Severn, one mile in length, running along the bridge at Sharpness, and another short cable running through the canal at Sharpness Docks.

With reference to

LINES PROPOSED,

it will be seen from the map that the company contemplate (we are informed at an early date) connecting their system with London, either through Bath, *via* Swindon and Reading, or by a line from Winchester through Basingstoke to Reading and the Metropolis. If the latter route be adopted, it will allow of the South Coast towns being put in direct connection with London, while a line from Winchester, *via* Salisbury, to Bath would connect Portsmouth with Bristol and Gloucester, and Bristol and the Welsh towns with London. Again, having established themselves at Portsmouth, the Western Company will only have a short distance to run (about eight miles) to the boundary of their district at Havant, where they could in the future make arrangements with the South of England Telephone Company to have trunk wires, connecting Brighton, Lewes, and Eastbourne, on the one hand, and Shoreham and Worthing on the other with the Western Counties' system, through a short line run between Worthing and Havant. This would put all these towns in connection with Portsmouth, Bournemouth, Winchester, etc.; in fact, it would place all the South Coast towns in intercommunication. We were informed that the proposal had been made to the South of England Company, but had been declined because they were unable to see that the proposed trunk lines

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would prove remunerative. Looking at the map, and from our knowledge of the towns, we should think they are making a mistake in declining the proposal of the Western Counties Company.

The whole of the Western Company's trunk lines have been constructed of hard drawn copper wire, and are all metallic circuits. They have at present 190 annual renters on these trunks; in addition to which they have, of course, a revenue coming in from the public call offices in the various towns, where for a fixed toll anyone not a subscriber can speak with any subscriber to the system.

The tolls from Bristol to the undermentioned towns, or *vice versâ*, are as follows, three minutes' conversation being allowed, viz.: Bristol to Bath, 6d.; Sharpness, 6d.; Newport, 6d. Beyond Newport, and as far as Pontypridd, including the towns in the loop, the toll is 9d.; and beyond Pontypridd, 1s. On the Bournemouth and Torquay trunks the toll is 6d.

To show the use that is made of these trunks, we may say that the number of calls by annual renters during the month of October last was 12,754; by local subscribers from their own offices, paying toll, 997; and by the public from the call offices, 686; making a grand total of 14,437 for the month, representing the user of the trunks. That they are growing in favour with the business community is shown by the fact that the figures for the previous October (1887) were: Calls from annual renters, 5,734; local subscribers, 310; public from call offices, 288; total, 6,332—that is to say, the calls have more than doubled in one year, which is pretty conclusive testimony of the value of these lines to the public, even allowing for extensions of the system.

Colliery Work.

The company have devoted considerable attention to providing telephonic communication for mines and collieries. The advantage of connection between the underground workings and the manager's office or house, and between the latter and the nearest town, is obvious, not only from a business point of view, but also in cases of accident or other emergency. When every colliery is provided with the telephone and every miner with an electric safety lamp, the risks now run will be diminished to a vanishing point. The company obtained a silver medal at the exhibition of the Cornwall Mining Institute held last year for the excellence of their work.

Instruments and Apparatus Used.

Being licensees of the United Company, the instruments used by the Western Company are, of course, those made under the Bell and Edison master patents, to uphold which the United has expended such enormous sums of money. Their system of working varies at different places. At Plymouth, Portsmouth, and Bournemouth they use the multiple board of the Western Electric Company. At Bristol they work an improved form of Bell board, and at other exchanges boards of various types but principally the Western Electric Company's standard pattern. Three kinds of wire are used, according to circumstances—viz., hard-drawn copper for the trunks, silicium bronze, $\frac{3}{16}$in. galvanised strand, as well as hard-drawn copper, for ordinary town work.

Number of Calls Per Annum.

During the year ending December last the total number of calls through the exchanges and on the trunk lines of the company was 1,937,000, and as each call necessitates a reply, the total number of communications over the lines during the above period was 3,874,000.

A Trial of the Trunk Lines.

Whilst at the company's offices our representative had an opportunity, thanks to the courtesy of Mr. Lewis, the general manager, of talking over the trunk lines which radiate from Bristol. At 4.33 p.m. he rang up for Gloucester, distance 39 miles, got through in less than half a minute, and made a few enquiries as to the weather, etc. At 4.35 rang up Bath, 12 miles distant, and got answer at once. At 4.36 rang up Cardiff, spoke them, and at 4.37 rang up Newport, but found them engaged with subscriber. Then asked for Swansea, and got through at 4.39, *via* Cardiff. Then asked Swansea to switch through to Llanelly, distant 128½ miles, and spoke them at 4.40. So that in seven minutes conversation was held with five different towns widely divergent (*vide* map) over a total wire distance of 363 miles. The conversation in each case was confined to two or three short questions and answers, chiefly referring to the weather, but quite sufficient to test the speaking properties of the lines. In each case the articulation was remarkably clear, and in only one or two instances was any repetition of a question necessary. Curiously enough, Llanelly, the furthest point spoken with, could be heard more distinctly than other places nearer at hand. This may, of course, have been due as much to the speaker as anything else. On the other hand, it should also be noted that the weather was very much against telephonic communication. There had been a strong gale over the district the night before, followed by heavy intermittent showers during the day, while every town rung up described the weather either as rainy or very damp.

With reference to the remarkably short time in which each town was "got" and spoken with, it should be remarked that at this time of the day the pressure of business had somewhat subsided, so that all the lines were clear with the exception of Newport. During the morning and early afternoon it is, of course, not unusual for subscribers to have to wait five or ten minutes before they can obtain the use of the line. In such a case a subscriber does not have to wait at the telephone during this interval. A record is kept by the operators in the switchroom of every call, and when the line is clear each caller is rung up and put through in his proper turn.

Even allowing, however, for the exceptionally clear state of the lines, our experience warrants us in congratulating Mr. Lewis and his staff on the excellent speaking properties of the company's system round Bristol, and, considering that no preparation whatever had been made for our trial, we think, even when it is allowed that the conversation in each case was very short, the time occupied was remarkably good.

General Remarks.

We will conclude with a few general remarks. And, first, we must say a word or two concerning Mr. Lewis, the genial and courteous manager of the company's system. Originally general manager of the old Bell Company, in London, Mr. Lewis has been associated with telephonic enterprise since the first introduction of Graham Bell's beautiful apparatus into practical everyday use. In June, 1880, upon the amalgamation of the Bell with the Edison Company—forming the present United Telephone Company—Mr. Lewis was made the metropolitan manager of the new concern, and shortly afterwards was sent into the West of England to introduce and work the system there. We understand that it was owing to his efforts that the Western Counties and South Wales Company was formed, he being appointed general manager and secretary. The history of the spread of the telephone over the district allotted to this company cannot be dissociated from Mr. Lewis's name. Thoroughly well up in all the details of his work, gifted with untiring energy and unfailing pluck, Mr. Lewis has amply justified the confidence placed in him by his directors, and it will not be his fault if the company's district is not soon a vast network of telephonic communication.

Throughout the company's exchanges women alone are employed by day and men or boys by night. Mr. Lewis expressed a very decided opinion in favour of girls, as compared with lads or men, for exchange work. With regard to the other side of the question—viz., the girls' appreciation of the work—he remarked with evident pleasure that since he had been connected with this company (1884 to present time) he had never had a girl leave his employ on her own account except to get married. We think this is good evidence of the existence of an excellent feeling between employer and employées, and also of the fact that telephonic work is well suited for the utilisation of female labour. Possibly in the future, when further developments have taken place and every town of any importance has its exchange, we shall hear

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less of the difficulty of finding suitable employment for "our girls." We were informed that girls have often left their employment in shops to come to the telephone company, and Mr. Lewis has a long list of names of those at present engaged in other vocations anxious to enter his employ when there is a vacancy, which list, he calculates, will be sufficient to supply him with employées for Bristol for the next five years. The exchange operators are very carefully chosen for the position, strict enquiries being made as to their respectability and fitness for the work. They start with a commencing salary of 6s. per week, and rise by gradual increments according to their merits, the chief operator in Bristol getting £1. 1s. per week. In other towns the pay is in proportion to the number of subscribers and the work to be done. The total number of the Western Company's employés is 260, of whom 84 are switchroom operators, 73 of these being girls. Night work is done by youths or men.

ELECTRICITY IN LONDON.

In our issue of last week, and also this week, we give a number of letters which have appeared in the *Times* upon this subject. On Thursday, our daily contemporary had a leading article based upon these letters, from which the following extracts are taken:

". . . . Hitherto the license and provisional order have lived side by side very amicably, for the apparent reason that there were no spoils to quarrel about. Electric lighting has for various reasons proved unprofitable to promoters. Since the passing of the Act of 1882 some 59 provisional orders and five licenses have been granted to companies, and fifteen provisional orders and two licenses to local authorities; and early last year it was stated in Parliament that the Board of Trade were not aware of any cases in which the powers thus obtained were being exercised. But within the last year or two electric lighting in this country has raised its head anew. How far the revival is due to the increased experience of electricians, how far to the success with which electric lighting has been worked in America, how far to last year's relaxation of the Act of 1882, or how far to generally stimulated trade, we do not profess to judge. We are inclined to think that the revival of electric lighting produced the Act of 1888 rather than that the Act revived electric lighting. However this may be, better days seem to be at hand. Some companies have been carrying on operations as best they can without either license or provisional order; several are about to apply for licenses; and two, anticipating the rest, have given the statutory notice of their intention to apply for provisional orders embracing the whole of the metropolis. The applicants for licenses only are indignant at this last piece of greediness, and thus the controversy of which we have spoken has naturally developed itself. The public will notice with some suspiciousness that the gentlemen by whom it is conducted are all directors or officers of rival electric lighting companies. We shall hardly be doing Mr. Hammond, Lord Crawford, and Mr. Erskine an injustice in supposing that their anxiety that the public should be well served is not entirely disinterested. Still, the self-denial of these gentlemen in ignoring all the private reasons which actuate them, and confining themselves to lucid statements of the public merits and demerits of provisional orders and licenses, is altogether praiseworthy. . . . .

"We desire to recognise the soundness of the principle which pervades Mr. Hammond's letter, that principle being the necessity of guarding against the creation of great monopolies. Taught by bitter experience, Londoners have every reason to be jealous of nascent undertakings for supplying them with light and water. But we may fairly consider that, in regard to electric lighting, public interests were sufficiently preserved by the Act of 1882, the safeguards in which were so stringent that they had to be relaxed in 1888. There are, in fact, two sides to the question. We do not want oppressive monopolies, but we cannot afford to throttle enterprise by stipulations which discourage investors. Lord Crawford declares that if the Board of Trade were to grant no provisional orders, but restrict itself to granting licenses pending the development of electrical knowledge, this would have just the same damping effect as the short tenure of 21 years and inequitable terms of pre-emption, which rendered the Electric Lighting Act of 1882 inoperative, and had to be altered by the Act of 1888. The requisite capital, according to Lord Crawford, could not be raised, for investors see no security and no prospect of adequate profits in the precarious tenure afforded by a license. To go back to a short tenure of not more than seven years just after Parliament has been driven to affirm the necessity of granting to the companies longer leases of life is a retrograde step. Such is Lord Crawford's view. It is almost impossible to lay down any hard and fast rule on the question. We can merely place the two principles —one directed against monopoly, the other against trammels upon enterprise—side by side, and observe that due weight must be given to each. We have full confidence that when it comes to particular cases the Board of Trade will use its discretion wisely. We should be sorry to see the entirety of the metropolis parcelled out among two or three companies on the principle of 'first come, first served.' We should be hardly less sorry if the Board of Trade, by any pedantic rules, checked for another interval the progress of electric lighting."

CORRESPONDENCE.

ELECTRICITY FOR HEATING PURPOSES.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Now that the supply of light and power to private consumers by a central electrical station is becoming so general, and as it is found to possess so many advantages, may I ask whether there is any greater difficulty in the similar supply of heating power by electric energy and transformations over the same areas? Surely there are simple methods of transforming electricity into heat, and this with but little loss of efficiency. Would not suitably constructed artificial metallic resistances easily adapt themselves to most of the purposes for which heat is required in dwelling-houses, without much outlay in plant, or complication of machinery?

Hollow tubes of very thin metal, or spirals of flattened wire in insulated chambers, would heat air (that would lose nothing of its purity by the process) in a most healthy manner, and which would serve many a useful purpose. Indeed, the advantages that would follow from the adoption of such a method of supply, I need not attempt to name; but think of the freedom from dust, dirt, coal, soot, ashes, *smoke*, and even fog, and tell me kindly, sir, why it is that this form of energy has to come to us in coal sacks; and whether our accumulators for it must always be coal cellars?—Yours, &c., HAROLD G. DIXON.

Guy's Hospital, S.E., January 4, 1889.

THE "MAXIM-WESTON" AND "HOUSE-TO-HOUSE COMPANIES.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—As many of your readers are aware, I have just succeeded (after three years of unremitting efforts) in inducing my fellow citizens to introduce the electric light into Bath for public and private use, and have obtained from the Corporation a seven years' contract (on behalf of a local supply company) for the public lighting of 50 of the principal streets, squares, and crescents of this city with arc lamps. Plant will shortly be put down for 200 arcs and 10,000 incandescents. I am not, as many suppose, a professional electrical engineer, but only an enthusiastic admirer of "the light of the future." During the past four years I have unstintingly spent my own time and capital in introducing electricity into several towns in the West of England, in the prosperity of which I am personally interested.

To my surprise, just as we are on the eve of forming our local company, the House-to-House make an application to the Bath City Council asking them to sanction their applying to the Board of Trade for a license for lighting the same area for the same term of years. What is the meaning of this application? Are the House-to-House Company imitating the behaviour of the Maxim-Weston Company when under the chairmanship of Mr Hugh Watt, M.P.? The unjustifiable interference of the Maxim-Weston, some twelve months ago, just as the Commissioners of Sewers were contemplating entering into a contract with the Brush Corporation for the lighting of the City was not only a loss to that particular company, but still more so to the whole of the electric lighting industry. The only effect of this application is to frighten a certain number of timid investors who will be afraid to apply for shares in the Bath Electric Lighting Company if labouring under the mistaken impression that it is going to be subjected to the competition of a powerful London company with an unlimited amount of capital behind it.

Even if the "House-to-House" possesses the necessary capital to erect a large central station, they would obtain no custom, as they could not compete with the local company except at a ruinous loss. The sooner companies which pursue this "dog in the manger" policy cease to exist the better it will be for the electric lighting industry, the growth of which they retard by their short-sighted policy. I trust that this candid expression of my views may produce beneficial results.—Yours, &c., H. G. MASSINGHAM.

[We think Mr. Massingham's views are those of all interested in the true welfare of the industry.—ED. *E. E.*]

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THE

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical-Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

OUTSIDE AND INSIDE.

Perhaps of all the lighting schemes that have been attempted, those at Barnet and Leamington have been subjected to the most violent criticism. It was our duty in schoolboy days to attend a series of lectures by an eminent lecturer whose subject was the rise and fall of various religious movements that had agitated the world. Very few of the worthy lecturer's remarks made a permanent impression, but one was forcibly impressed to the effect that religious or any other movement—for the moral was widely applicable—went wrong rather from internal dissensions than from external attacks. We humbly apologise to the rev. lecturer for the base use to which we are applying his conclusions, viz., that if the electric lighting industry, instead of progressing and flourishing, goes backward, the result will arise from internal and not external causes. Now we are not going to trouble our readers with many words about internal criticism, which, though the most dangerous, is not likely agaiu to become prominent without some extraordinary mistake on the part of electrical engineers. What we wish to refer to is the attitude of the ordinary local and metropolitan press. Most writers, however ignorant upon technical matters, believe themselves quite capable of determining the photometric power of rival lights. Then they imagine they know all about gas. They admire the simplicity of its distribution and ease of manipulation. It is a tool they are familiar with, while we would hand them a tool about which they have heard much and experienced little, hence "the bird in the hand is worth two in the bush." Again, most of the gas companies are local concerns, and whatever affects gas, affects the pockets of shareholders. Usually some member or members of the local board or town council are directors of the gas company, and of course anything about electricity provides the red rag at which the bull incontinently rushes. They are in possession, and strenuously defend themselves against attack. The local press deals with local politics, and reports at great length the sayings and doings of those connected with gas companies—because they are so connected. The men who wish to introduce improvements are generally looked upon as busybodies, as men who can't let well alone, and are not infrequently the best abused men in the town. The external attacks, then, upon the electric lighting industry come from these quarters, and cannot be said to be the outcome of knowledge, but are the natural features which must always accompany change. Of course, the technical journals connected with the gas industry follow the cue given them by the prominent members of the profession. They can hardly be expected to view the progress of electric lighting with feelings of unmingled gladness. If any man is desirous to see the worst that can be

said or thought about electric lighting, let him read the weekly gas journals. It has been again and again suggested to us that the peculiar twisting, plain simple facts undergo at the hands of writers in these journals, to make them appear somewhat different to what they really are, should be "shown up," but our invariable reply is that such criticisms show the wish to be father to the thought, while, in the long run, they are comparatively harmless. They come from interested quarters, and are usually taken *cum grano salis*. Now, both external and internal criticisms have been hurled against Leamington and Barnet. The commencement of this year of grace sees success at both places—success absolute, even if not unqualified success. With regard to Leamington, the lighting is of two kinds—public and private. There have been continuous squabbles about the former, none about the latter. Both the lighting of private houses, places of amusement, shops, etc., and the street lighting of the parade are carried out by Messrs. Chamberlain and Hookham from the same central station, and while they have always been able to give entire satisfaction to their private customers, they have never been able to satisfy the town council as to the street lighting. At present more than double the light is given than used to be given with gas, yet the powers that be are not satisfied. Is it that they want artificial moonlight or sunlight, but are not willing to pay for it? The charge for the street lighting is not equal to 3d. per unit, and when we have said this, it is sufficient to explain that the suppliers are more or less indifferent to the continuance of this particular lighting. An extension of house-to-house lighting would pay better and be more satisfactory to all the parties concerned. We take it that the inability to satisfy the council means simply inability to satisfy the gas interests represented on the council. With regard to Barnet, the contractor, Mr. Joel, has had by no means an easy or happy time. The suggestion to light electrically began, we believe, with a squabble with the local gas company, and it was not likely the gas interests were or are going to cry peccavi without a hard struggle. The gas company thought to put pressure on, and have its own way. The rival is steadily forcing its way against all opposition into popularity. Before leaving this part of our subject we may direct attention to the letter of Mr. Massingham from Bath. We do not hear of a second gas company trespassing upon the local habitation of another local company. Surely the country is wide enough without these internal dissensions. These actions are more dangerous than all the open or covert attacks from gas. The company referred to could hardly be unaware of the work done by Mr. Massingham to influence the rulers of his native city to adopt the electric light.

Let us again suggest that more money is to be made by installing a *light* and *power* station in a working neighbourhood than by installing a light station in an aristocratic neighbourhood. You engineers fight shy of power, you only refer to it as holding a secondary position. We think it far more probable that even in the immediate future power will take first, and light have to be satisfied with second place. Try it. Canvass for power as assiduously as you canvass for light. You will be astounded at the promise of return that distribution of power gives in comparison with that of distribution of light. The small consumers of power consume it in the most wasteful and uneconomical manner possible, and they probably pay for a single horse-power fifty or a hundred times as much as is paid for a horse-power by a railway or a ship owner. The English engineer seems perfectly blind and helpless in this question of power. He is probably waiting till his American confrère steps in and shows him how it is to be done, when he will scream at the go-ahead Yankee for trespassing upon the home preserves. We have no sympathy with this state of things. If the English engineer won't, then let the French, German, or American come in. There was an absurd suggestion made by one of our contemporaries the other day about driving Wimshurst machines to dissipate fogs, showing how utterly ignorant the writer is of the first principles of business. He might have written, "Burn coal, burn it wastefully, burn more to drive machinery to get rid of what you are burning wastefully." Artemus Ward would have said, "Sound advice, truly," but we would rather see no coal burnt wastefully. We know that Yorkshiremen believe that where there is "no muck there is no money," but it may well be doubted whether too much muck increases the money. Do doctors advise the slashing of an arm or leg an extra inch or two just for the mere purpose of adding another plaster? Where is now our old copybook headline, "Prevention is better than cure," which used to be looked upon as axiomatic, but some people have lost faith in it, and read it the other way up, "Cure is better than prevention."

Morals for this week:

Internal dissensions are worse than external attacks.

Power and light rather than light alone—hence working not aristocratic districts for central station installations.

Report of 1888 Continued.

Blakey, Emmott, and Co. have been exceedingly busy during the past year in their numerous departments of electrical engineering and electric light. A large demand has ruled for their new type of single magnet dynamo, and some good orders have been obtained from abroad. Numerous factories, public buildings, and private mansions in the North of England have also been lighted by

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this firm. In their instrument department the "Blakey-Emmott" volt and ammeter have been in large demand, we suppose by reason of the non-liability to get out of adjustment and easy portability. The "Robinson" lamp, which is introduced by this firm, promises to occupy one of the leading positions among arc lamps, and we hope to describe and illustrate it at an early date. The company are also exceedingly busy in their cable and wire departments, having during the last year greatly extended this branch, and are now working night and day to fulfil their orders, they making several special classes of electric light cables and leads, which have found very great favour abroad.

DRAKE AND GORHAM have completed a large number of isolated installations during the past year.

At the Bank of England a steam-engine of 50 h.p. has been put to work for lighting purposes, and two large gas-engines will be started in a few days to supply another portion of the bank. Several of the more important offices are already fitted with incandescent lamps, and it is expected that before long the gas will be used only in the corridors and offices of minor importance.

The incandescent installation at the Prudential Assurance Company's office has been completed, and the plant is capable of supplying 3,500 60 watt lamps, and may therefore be regarded as a central station in itself. The plant consists of three Marshall horizontal engines of 110 h.p., six 600 light dynamos, and 264 cells, made to the firm's latest specification.

An installation has been fitted at Baron Schroeder's country residence, with two gas-engines, and the whole of the lighting at Lord Armstrong's seat, Cragside, has been rearranged and extended, Elwell-Parker dynamos and motors being substituted for those previously in use for both lighting and motive power.

Complete installations, with plant, have also been carried out for A. S. Freeman-Mitford, Esq., the Society of Antiquaries, Sir William Plowden, K.C.S.I., Messrs. Johnson, Budd, and Johnson, S. Courtauld, Esq., Alfred Apperby, Esq., F. E. Marshall, Esq., Harrow Schools, J. Saunder-Gilliat, Esq., A. Kingsmill, Esq., W. Abercrombie, Esq., and ship-lighting batteries fixed on H.M. the Queen's yacht, H.R.H. the Prince of Wales's yacht, H.M.S. "Britannia," and a number of private yachts and steamships.

Several improvements in accumulator plates have been patented and put into work during the year, which are already found to be a material advance. A number of electrical hoists have been erected for various purposes.

The firm is paying special attention to the production of measuring instruments for regular work, and has purchased the Cardew patents for voltmeters and brought out a new pattern ammeter of its own.

ELWELL-PARKER, LIMITED.—This company has had, on the whole, a very prosperous year. They have increased their establishment and the number of employés, until the latter number 430; and the works at present are running with a night and day set, with plenty of orders in hand. The company has in the year increased the alternating-current plant at the central stations of Eastbourne and Brighton, and supplied a full central station alternating-current plant to South America. The whole of the plant is now supplied to the House-to-House Company's station at South Brighton, and they have also supplied the whole of the plant for two other central stations, also the accumulators for that at Liverpool. They hold orders for Whitehall, Leeds, and further orders for Liverpool, Brighton, and Melbourne. This company has during the year supplied and tested thoroughly in Wolverhampton, in the presence of many distinguished gentlemen (including the directors of the Manchester Carriage Company, representatives of the borough surveyors, Birmingham, and the various technical press), a car built to the Julien lines for Mr. E. Pritchard, Sydney, who has since demonstrated sufficiently in Sydney the advantages of accumulators to be able to obtain several large contracts. They have added to this an experimental locomotive, built also for the Julien Company, of England, and made to compete with the steam tram-engines in Birmingham. This has been placed in the hands of the Central Tramway Company, Birmingham, for this purpose, and has been submitted to the severest possible tests over an extended period of two months, having given thorough satisfaction to the tramway company and the borough authorities, and seems to have attained a thoroughly practicable issue for the application of accumulators to the purpose of driving tramcars. They have recently supplied further motors to the Brussels Tramway Company, to be used with accumulators for tramway work. These are repeat orders, the company having supplied the earliest motors. Motors have also been supplied to the Series Traction Syndicate for their new line at Gravesend, and a complete tramway plant for overhead driving to Australia. The plant at the General Post Office has been extended during the year, and orders are in hand for further increasing the plant for the Savings Bank Department. Dynamos have been supplied to various Government departments. Our readers will also remember that Messrs. Elwell-Parker supplied the plant for the installation of the Corporation-street Estate Company at Birmingham.

FOWLER, LANCASTER, AND CO.—Like most of the firms engaged in electrical work, the report of the work throughout the year is favourable. The whole twelve months have been exceedingly busy, especially in the manufacturing department, the business of which has so much increased that arrangements for the extension of the premises have been made. An enormous quantity of switches, cut-out cases, fuse-boxes, ceiling and wall connectors, and lampholders, etc., have been turned out in china, which this firm were the first to perfect with regard to the screwing together of the bases and covers, and in this department has been more than filled with orders, and there are now sufficient orders in hand to be very busy for some time to come. A considerable business has been done in railway and instrumental work.

Among other contracts that have been carried out, is that of the lighting of a portion of the works of Messrs. Perry and Co., of Birmingham, by 400 incandescent lamps of 6 c.p., each of which replaces a 4ft. gas-burner, the result being that, after keeping most careful statistics, it has resulted in a saving over gas, and a considerable decrease in the expense for doctor's attendance to the female hands employed. There were also about 40 lights of 16 c.p. in the office of the company. In addition to the above, an installation has been put in at the residence of Martyn Smith, Esq., of Abberton Hall, Pershore, including a 50-light Fowler-Lancaster dynamo, driven by a Spiels petroleum engine and a set of E.P.S. accumulators; also an installation at the residence of W. E. Wiley, Esq., of Erdington, consisting of 75-light Fowler-Lancaster dynamo, which is driven by an Otto gas-engine. These are instances of installations carried out under somewhat unusual conditions, each of which has given the utmost satisfaction, and in the case of Messrs. Perry and Co. the contract is in hand for an extension of lighting, to the entire replacement of gas in the works.

A good deal of work has been done in wiring and fittings, and an extensive trade in switches, etc., both at home and abroad.

GENERAL ELECTRIC COMPANY.—This company have strictly adhered to manufacturing for the trade only. The business is in two departments, both of which have been fully employed during the last twelve months. The electric light department did a very considerable turnover in the supply of a great number of "Apostle" carbons, glass shades, and other electric light fittings. In order to obtain increased facilities to extend the business for switches and fittings, the works formerly carried on under the name of Sudworth and Co., Limited, have been bought and have been considerably extended. At the same time the firm has acquired the Manchester Electric Works, 45, Chapel-street, Manchester, in which there is room to occupy 400 to 500 men, though at the present time only about half that number are employed. The sale of instruments, more especially Aron meters, has increased with the number of central stations which have appeared in the last year, and in this department they look forward to a bright future.

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The strict interference of fire insurance companies with contractors has, if anything, been a great advantage, in so far as the demand generally is now for goods of a high standard, and the firm has supplied a great number of elaborate switchboards, the orders for which, it is believed, are entirely due to the strict specifications insisted upon by the fire offices. The demand for English manufactures on the Continent and in the colonies has shown a considerable increase during the last year, though this increase is more noticeable in the electric bell department, where, especially from Australia, extensive orders are received by every mail. This department has also increased proportionately to expectations, and it is satisfactory to see daily new firms interesting themselves in this branch of electricity.

GALWAY ELECTRIC COMPANY.—It may interest our readers to know that out in the far West of Ireland electric lighting is making its way. For some time the Galway Company have illuminated a part of the old town with arc lights, and are busy now with incandescent lighting for private work, and they have, we are glad to find, a number of enquiries for motive power. This is a private local company, represented professionally by Mr. James Perry, M.E., the county surveyor of Galway, and Mr. Arthur W. Slater, A.I.E.E. The company has acquired some extensive works, with ample water power, and have made arrangements for more power should they at any time require it. The proposals for lighting the town are being considered, and it looks a good sign that the commissioners have informed the gas company that their arrangements with them may end with the financial year.

J. H. HOLMES AND CO., Newcastle-on-Tyne, and 17, Coleman-street, London, have been very fully employed during the year, and have been obliged to run their factories night and day for some months past in order to cope with the demands placed upon them. The firm have carried out a large number of installations in mills, shops, etc., but the greater part of their business has been done with electrical engineers at home and abroad.

LIVERPOOL ELECTRIC SUPPLY COMPANY.—During the past year the Liverpool Electric Supply Company have very largely extended their system of supply. They have now three central stations in use, and are supplying daily about 3,000 incandescent lamps and a small number of arc lamps. The company are engaged in laying a system of underground mains on the Callender system in the chief streets of the business portion of Liverpool.

ELECTROLYSIS OF COPPER SALTS.

BY ALEXANDER WATT.

With the exception of the sulphate, the cyanide and some few other copper salts, the electrolytic examination of solutions of this metal does not appear to have received so much consideration as the subject merits—not alone from the interest which always attaches to the electrolysis of metallic solutions, but also from the possible advantages which such experiments may offer to the practical operator, which latter consideration, I may frankly state, has always been paramount in all investigations of this character which it has been my pleasure to conduct. In carrying out the experiments to which I now desire to direct attention, the current was obtained from a modified Daniell battery which I invariably use for such purposes, owing to its regularity and constancy, and the very little attention required to keep it in working order. This arrangement consists of a quart stone jar, in which is placed a cylinder of sheet copper with conducting wire attached; a porous cell, in which is a cast bar of zinc, amalgamated, and having a conducting wire cast into the metal; the outer vessel is filled with a saturated solution of copper sulphate, slightly acidulated with sulphuric acid, and the porous cell filled with a 1 : 12 solution of sulphuric acid. About half a dozen of these cells are kept ready for immediate use, the current from one cell being always tried first, and one or more cells connected in series as required. The E.M.F. of this battery, as measured by the Walsall Electrical Company's voltmeter—which, by the way, is a very delicate instrument, and well suited for electroplaters—is 1 volt, and the current, measured by a Siemens' dynamometer, 1·073 ampere. The anode consisted of a plate of electrolytic copper, to which was soldered a copper conducting wire; and the cathode, in most instances, consisted of a steel plate one inch wide and about three inches long. All the solutions were electrolysed at the ordinary temperature.

In pursuing the experiments, it was determined to pass by such electrolytes—ordinary sulphate of copper solutions, for example—as were more commonly known, and to devote attention more especially to those which had received less consideration. Moreover, well knowing the difficulty of obtaining thick deposits of copper upon iron in sulphate baths, without giving the work a preliminary coating in an alkaline coppering solution, and the defects which cyanide baths present for this purpose, it was my desire, if possible, to find out some solution of copper which, having no chemical action *per se* upon iron, might be practically employed as a substitute for the cyanide baths ordinarily used.

1. *Oxide of Copper in Chloride of Ammonium.*—A hot solution of salammoniac was first prepared, and to this was added, a little at a time, recently precipitated hydrated oxide of copper, until the ammonium salt became sluggish in its solvent action, when the liquid was set aside to cool and settle. The resulting solution, which was of a pale blue colour, was then decanted for use. A steel plate being immersed in this solution for a minute or so became very slightly and partially coated with copper. It was next tried with the current from a single Daniell, when a steel plate at once received a film of copper; after a few seconds, however, the metal assumed a dark purple-brown colour. On wiping the plate with the finger, this brown deposit became dislodged, leaving a bright film of metallic copper beneath, which was very adherent, and firmly withstood hard scrubbing with moist silver sand. The solution was next diluted with water, after which deposition took place more gradually, and the film continued bright for a much longer period. After a few minutes, however, the deposit again assumed the purple tone, from the formation of powdery metal, but when this was removed by scouring, the subjacent layer of copper was found to be firmly adherent. By further dilutions of the solution it became greatly improved, and the non-adherent coating almost ceased to appear.

2. *Oxide of Copper in Sulphate of Alumina.*—A bath was prepared by digesting moist hydrated oxide of copper in a hot solution of commercial sulphate of alumina, in which the oxide became very freely dissolved, forming a green liquid. When cold, the clear liquid was first tested with a steel plate, which, by simple immersion, soon became coated with a firmly-adherent film of copper. The solution was next electrolysed with a single cell, a steel plate, as before, being used as a cathode, and this promptly received a film of copper, but as the deposition was too speedy for an adherent coating, it was found necessary to dilute the liquid by repeated additions of water until deposition proceeded more gradually, when the deposit eventually became firmly adherent, though somewhat wavy and irregular in appearance, the final dilution having been carried too far.

3 *Acetate of Copper.*—A solution of this salt was prepared by dissolving verdigris in hot commercial acetic acid, the resulting solution being afterwards filtered and diluted with water, in varying proportions, until the copper deposited upon a steel plate became more or less adherent. It was not until the liquid had been considerably weakened that the metal exhibited a disposition to adhere to the cathode. The current from one cell was used, with a small anode surface, and it was found that the metal was more adherent when the steel plate was kept briskly in motion while in the bath.

4. *Acetates of Copper and Soda.*—A small quantity of acetate of soda was added to the above solution, in the hope that this would cause the copper to adhere more firmly to steel or iron, and such really proved to be the case, for the deposited metal now required hard scrubbing with sand

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to remove it from the plate. There was, however, still a tendency for the copper to strip or peel off certain parts of the plate. On examining the anode it was found to be coated with a deep orange-red film of oxide, which was readily removed by dipping the plate in hydrochloric acid. By simple immersion a strip of sheet iron did not become coated with copper in this solution.

5. *Acetate of Copper by Electrolysis.*—About equal parts of commercial acetic acid and water were put into a glass vessel, and in this liquid was immersed a pure copper anode and a platinum cathode, and the current from two Daniells allowed to pass, when in the course of a few minutes the platinum acquired a slight film of copper. A steel plate was then substituted, which soon received a coating of copper, but the metal was not adherent. A freshly-prepared plate was then immersed, and briskly moved about in the solution for several minutes, when it was found that the copper adhered firmly to the steel. The bath was afterwards strengthened with metal by immersing a large copper anode and small strip of the same metal for the cathode, and the electrolysis sustained with the current from two cells for some hours, after which the resulting solution was diluted with four times its volume of water. This solution, worked with a single cell and small anode surface, failed to yield a perfectly adherent film of copper when the steel cathode was allowed to remain stationary in the bath, but, as before, a more adherent coating was obtained when the plate was kept in motion.

6. *Sulphates of Copper and Ammonium.*—The object of this experiment was to ascertain whether the addition of the ammonium salt to a solution of sulphate of copper would promote the adhesion of copper to steel or iron, which it is well known cannot be successfully accomplished in solution of the simple sulphate. For this purpose, about equal parts of the respective salts were dissolved in hot water, and the liquid then set aside until cold, when pale-blue crystals of the double salt were found at the bottom of the vessel. The concentrated solution was next diluted with an equal bulk of water and electrolysed with one cell, when it was found that the deposit of copper upon a steel surface was tolerably adherent. Fresh additions of water were afterwards made, a new steel plate being immersed after each addition, and it was found that the adherence of the deposited copper was progressively better as the liquid became more dilute. Although the mixed salts certainly yield a more tenacious coating than could be obtained from the sulphate alone, it cannot be said that the solution referred to would be absolutely reliable as a coppering bath so far as the tenacity of the deposited metal is concerned. On examining the anode it was found to be coated with a yellow film, a portion of which firmly adhered to the plate. A solution was next prepared, by dissolving the crystals of the double sulphate found in the foregoing concentrated solution, in cold water. This bath was then tried with the current from a single cell, when the steel cathode soon became coated with a golden or orange-coloured film, changing to bright yellow, while patches of a purple tint appeared upon portions of the plate. On removing the plate, and scouring it with silver sand, a pale copper film became exposed, which adhered fairly well to the steel surface. On returning the scoured plate to the bath and keeping it in motion, a tolerably adherent film of copper was obtained, but this again assumed various coloured tints when allowed to remain stationary for a few moments.

7. *Sulphates of Copper and Alumina.*—Weak solutions of the respective salts were mixed, and the compound solution worked with a single Daniell cell. On immersing a steel cathode, a wavy, irregular film was at first obtained, when the plate was removed and rescoured with silver sand; soon after it was returned to the bath the film at once assumed a golden-yellow colour, which, but for the results obtained in the preceding solution, might have suggested that possibly a small quantity of aluminium had deposited with the copper, forming aluminium bronze. It was certainly remarkable that the same yellow deposits were obtained in each case. The yellow film referred to required hard scrubbing with sand to dislodge it from the steel plate.

8. *Potassio-tartrate of Copper.*—To form a solution, 120 grs. of bitartrate of potassa (cream of tartar) were dissolved in about eight ounces of hot water, and to this solution was added, by degrees, moist hydrated oxide of copper, the mixture being boiled after each addition of the oxide, which freely dissolved in the tartrate solution, forming a dark-blue liquid. The vessel was then set aside until cold, when the clear liquid was decanted for use. A steel plate slowly received a bright coating of copper in this solution by simple immersion. The liquid was next tried with the current from a single Daniell, a platinum cathode being used, which became slowly coated with copper of a darkish colour, while the edges of the anode, which did not appear to dissolve in the solution, became fringed with a bright green salt, the remainder of its surface being marked by vertical streaks of a brownish colour. A steel cathode was next used, when the green powder at once disappeared from the anode, but this electrode still remained "dirty," however, as though it were but little acted upon by the solution. Almost immediately after immersing the steel plate it received a film of copper of good colour when kept in motion, but when allowed to rest undisturbed for a short time the deposit acquired a dull and darkish tone. The film was non-adherent. The liquid was next diluted with an equal bulk of water and a fresh plate immersed, when a very prompt deposit of copper was obtained, which, as before, was non-adherent. Repeated additions of water were afterwards given, with a view to obtain a coherent deposit, but although the adhesion of the copper greatly improved after each addition of that liquid, the final result was not altogether satisfactory. A solution of this character was tried by Smee, who held the opinion that the anode is very slightly acted upon in a solution of the potassio-tartrate, and my own experiments certainly sustain that view. Dr. Elsner, however, asserts that the anode dissolves readily in such a liquid. By the simple immersion method this solution deposits copper of good colour, and very adherent upon steel, and probably it might be useful for coppering small steel articles, as buttons, etc., to be afterwards bronzed by a solution of potassium sulphide or other suitable material.

8. *Chloride of Copper.*—A solution of this salt was prepared by dissolving 120 grains of the crystals in eight ounces of cold water. The current from a single cell was used, and a very small surface of anode immersed. A very quick deposit of copper was obtained upon a steel plate, but the film was readily scoured off with moist sand. The solution was then diluted with an equal bulk of water, when deposition was still too quick, and the metal non-adherent, as before. After further dilutions with cold water the metal adhered more firmly to steel, but not sufficiently so as to render the solution practically available—that is to say, reliable. The anode did not keep clean in this bath, but became coated with a yellow deposit.

9. *Chlorides of Copper and Ammonium.*—Salammoniac (chloride of ammonium) was added to the foregoing solution with a view to improve the character of the deposit so far as relates to its adhesion to steel and iron. The addition of the ammonium salt was found to act beneficially in this respect, especially when the steel plate was kept moving in the bath, and, indeed, the deposits obtained in the altered liquid were so far adherent as to withstand the pressure of a steel burnisher without stripping or blistering in the least degree. It is not improbable that a solution carefully prepared from these salts might be useful as a depositing solution, more particularly if the articles could be kept gently in motion while deposition is taking place. This bath, however, would be useless for coating zinc articles, for a strip of this metal acquired a deep black colour a few moments after immersion. It should be mentioned that the anode after a time assumed a deep red colour.

10. *Chlorides of Copper and Sodium.*—A solution was prepared by adding to a weak solution of chloride of copper, in small quantities at a time, chloride of sodium (common salt), which was dissolved into the liquid by stirring. This bath was electrolysed with the current from one cell, and its behaviour may be said to be precisely similar to the foregoing in every respect—the anode, as before, acquiring a deep red colour. A steel plate, when briskly agitated in

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this solution, received a firm coating of copper of good colour.

11. *Chlorides of Copper and Potassium.*—Small quantities of chloride of potassium were added successively to a weak solution of the copper salt, a steel plate being tried after each addition. Although there was a close similarity between this and the two preceding solutions, the results obtained from the present combination were scarcely so satisfactory. It was noticed that when a steel plate was immersed in this bath for a few seconds—a single Daniell being used—that the film of deposited metal acquired a deep red colour, turning somewhat purple after a while.

12. *Ammoniuret of Copper.*—A solution was prepared by adding liquid ammonia to a solution of sulphate of copper until the precipitate at first formed became dissolved; this solution was then tried with the current from one, two, and three cells in succession, but even with the latter, in series, there was a very slight tendency for the copper to go down on a steel plate.

13. *Ammoniuret of Copper and Salammoniac.*—A small quantity of salammoniac was added to the foregoing solution, and dissolved with stirring. On immersing a steel plate (the current from two cells being used) this at once became coated with a bright film of copper, which was found to adhere to the steel very firmly. A plate of zinc immersed in the liquid readily became coated with copper, which at once alloyed itself with the zinc, forming a yellow film of brass. A solution of this character might be useful for coating iron and steel.

14. *Arsenite of Copper in Cyanide of Potassium.*—To a hot solution of cyanide of potassium was added, in small doses at a time, arsenite of copper, and the mixture stirred until the copper salt was dissolved. The object of this experiment was to ascertain whether an alloy of copper and arsenic would deposit from this solution. Such was not the case, however, for the cathode (a steel plate) became coated with an iridescent film—first blue, then yellow, followed by red, yellow, and blue again, but there was no appearance of metal as such.

15. *Arsenite of Copper in Hydrochloric Acid.*—The green salt was added to hydrochloric acid, and heat applied until it became dissolved, forming a yellowish-green solution. This was next diluted with water, when the liquid at once became colourless. With the current from one cell a steel plate received a black deposit of arsenic at its lower end, while a band of copper appeared upon its upper surface, and the intermediate deposit between these two films appeared to be an alloy of the two metals, copper and arsenic. When a freshly prepared plate was kept in motion, while in the liquid, a bright film of arsenic appeared at the lower end of the plate, a streak of copper above as before, while the surface between these deposits had a yellowish tint, which was doubtless an alloy of the two metals. The solution was now further diluted, and a steel cathode allowed to rest in the solution for a short time, a very small anode surface being immersed. On examining the plate after a few minutes, it was found that a bright film of arsenic had deposited upon both sides of the plate, but when this was again moved briskly about in the bath patches of copper appeared at the back of the plate. The anode was freely dissolved in this solution.

(To be continued.)

ELECTRIC LIGHTING OF THEATRES.—II.

We sketched out in our first article some of the general advantages of electricity over gas for the lighting of theatres, and we shall proceed to describe in detail the various theatre installations in London. Besides particulars of the plants laid down, and of the numbers and arrangements of the lamps lighted, we shall endeavour to give the opinions of the managements and of the engineers in charge, as far as we have been able to obtain them, with regard to the advantages which in their own theatres they consider specially important in the use of electricity for lighting, with any other details of a similar kind which are the result of experience. The articles will be submitted in proof to the management and the engineers, and will thus bear, as far as possible, a certain authoritative value.

The consideration of a connected series of installations for the one special purpose of theatre lighting, together with the result of the practical experience now obtained, should lead to useful information to those who are likely to be engaged in this class of work.

ALHAMBRA.

The introduction of the electric light into this theatre has been eminently satisfactory to the management. The auditorium—with the exception of the gallery—and a portion of the stage is at present electrically lighted, and the plant they possess is fully loaded, but we believe that the directors only wait to be further assured of the reliability of supply of electric energy by public companies before deciding to receive the current they require from outside, and to light the whole of the stage as well as the house. The plant is situated in the basement below the dressing-rooms and wholly behind the proscenium wall; it consists of two Otto gas-engines of 9 h.p. nominal each, of two Edison dynamos, and of two sets of accumulators containing 54 cells in each set. In order to ensure great steadiness in the light, each gas-engine has two flywheels, and the dynamos, which are driven by belting direct without counter-shafting, have also each a small flywheel. The dynamos are shunt-wound for an E.M.F. of 110 volts, and the average current they furnish is about 80 amperes. There are two sets of accumulators, of the Elwell-Parker type, of 23 and 31 plates per cell respectively, with a capacity of 1,200 ampere-hours; these are contained in a separate cellar.

The resistances used for varying the degree of light from the foot-lights are of hoop-iron, and six degrees of light are possible. The instruments used in the engine-room are an ammeter and a voltmeter of the Ayrton and Perry spring form, and a Sharp and Kent ammeter. The float, the pit floor, and the grand circle floor are lighted direct from the dynamos, and one set of the accumulators lights the top balcony, the other set being kept in reserve.

In the float there are 80 16 c.p. glow lamps; on the pit floor 61 16 c.p., and four 32 c.p. lamps, the latter being over the bars; and in the balcony there are 104 16 c.p. lamps. The electric lamps are arranged for the most part round the auditorium in elegant brass brackets, each of which carries three incandescent lamps, and have a very pleasing effect.

The whole of the work, including the fittings, are by B. Verity and Sons, of King-street, Covent Garden. The gallery is still lighted by gas, as may be seen on looking up from the stalls by the flickering of the light, while the light emitted by the glow lamps is absolutely steady. We are told that the behaviour of the plant has been perfectly satisfactory, and that no trouble at all has been experienced with it from the commencement.

The cost of lighting since the introduction of the electric light has been about the same as before, but more light is obtained. No reduction in the insurance has yet been obtained in this theatre by putting down an electric installation, although the building has the further advantage of being constructed with concrete and iron, and is therefore of fireproof construction. The theatre was redecorated in April last, and it is stated that a marked difference in the rate of tarnishing has been observed, to the advantage of electricity.

The management consider that the absence of ascending streams of heated air from the foot-lights is very important, as the actors can with ease and comfort approach the very front of the stage. In the ballets this is really equivalent to an enlargement of the stage, and that in the best direction—viz., towards the audience. Great stress is also laid on the advantage of the general coolness and purity of the atmosphere in the auditorium of the Alhambra since the lighting of it by electricity.

Special Effects.—The electric light is occasionally used for special scenic effects at the Alhambra ballets. In one of the recent dances the fairy carried a 50 c.p. incandescent lamp, with a reflector throwing a strong beam of light from her head towards the audience with dazzling effect. This

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was obtained by running a lamp of very much lower voltage—say, 90 volts or so—on the 110 volt circuit. A brilliant light, nearly equal to an arc, was thus produced, but of course could not be kept on for more than a few minutes each evening.

In the new Christmas ballet, "Irene," the electric light forms a feature in one of the scenes with very pretty effect. A large number of 5 c.p. lamps are used, on a blue background, to represent stars brightly shining on a moonlight night.

ELECTRIC LIGHTING.

LICENSES OR PROVISIONAL ORDERS.

The following letters have appeared in the *Times* upon the subject of Mr. Hammond's letter, as given on page 9 last week:

"Sir,—My attention has been called to the letter appearing in your issue of the 3rd inst. respecting the correspondence between Mr. Hammond and the Board of Trade as to granting licenses under the Electric Lighting Acts.

"As my company is the only company in London which has been working under a license from the Board of Trade, I feel it would be unfair to the immediate prospects of electric lighting in the metropolis to allow Mr. Hammond's attack on the industry to remain unanswered.

"The chief point to which I desire to call your attention is the inaccuracy of Mr. Hammond's suggestion that no district lighting has yet been so satisfactory in the metropolis as to warrant the apportionment of the metropolitan area by means of provisional orders, and that no district lighting whatever has been carried out over an extended area by means of underground mains. My company, or rather the Kensington Court Electric Lighting Company, by which name the company was known before extension, has been supplying the electric light to residences in the vicinity of Kensington Court for the last two years. Throughout the whole of that time there has only been one partial stoppage and lowering of the illuminating power, which lasted for less than one hour and a half (between 4 and 6 p.m.,) and occurred at a time when necessary changes were being made with a view to the extension of the supply. With this single exception the light has been supplied by meter throughout the whole period in question day and night without intermission, and with the same regularity as gas.

"Moreover, the mains of my company are laid entirely underground, in pursuance of powers granted to them by the Board of Trade with the consent of the local authorities. I submit, therefore, that the experience of my company is sufficient to show that the time has now come when provisional orders may be granted with due regard to the interest of the public, and I would point out, moreover, that it cannot be expected that the light will be supplied on any greatly increased scale except under the protection which a provisional order alone can give.

"It is for this reason that my company are now applying for a provisional order in Kensington and Knightsbridge, and I am surprised that Mr. Hammond should put forward reasons against the granting of provisional orders, seeing that the House-to-House Company, which he represents, is making a similar application. I trust that Mr. Hammond's company, when they start supplying electricity, may prove that the system adopted is worthy of public support, but that in the meantime nothing will be done to check the advance which, after so long a delay, has been brought about in the electric lighting of the metropolis.—I am, your obedient servant,

"R. S. ERSKINE, secretary Kensington
"and Knightsbridge Electric Lighting
"Company, Limited,

"Kensington High-street, London, W., January 5."

"Sir,—A day or so since a letter was addressed to you by Mr. Robert Hammond, of the House-to-House Electric Light Supply Company, on the question of giving permanent tenure to undertakers for supplying metropolitan areas.

"I will not trouble you with regard to Mr. Hammond's correspondence with the Board of Trade; the accuracy of the statement which I made on December 21 as to the decision come to by that department is sufficiently shown by the paragraph, apparently communicated officially, which appeared in most of the London papers on the 2nd inst.

"The remainder of Mr. Hammond's letter is a series of arguments in favour of procedure by way of license as against provisional orders, and yet I see in the *London Gazette* of November 23, 1888, the advertisement by his company of their intention to apply to Parliament for a provisional order; consequently his conversion to the other method must be of recent date.

"I will take his arguments in order:

"1. He says that no district lighting has been done by underground mains so as to warrant the granting of provisional orders.

"True, with the exception of the Kensington Court Company, those who have been in possession of licenses or orders in the metropolis, Mr. Hammond among them, have done nothing whatever underground or overhead, and it could only have been done by them, as those not under the Act were unable to place mains underground. On the other hand, great attention has been paid for some years past to the distribution of current by means of overhead conductors, so as to combine with economy the *maximum* security against all dangers. I think I may claim that the experience thus gained will render underground work comparatively easy.

"2. He says that it is against the interests of the public to be served by companies who are unable to carry on the work; and till the new companies have proved by natural selection which is the fittest, no provisional order should be granted.

"To the first portion of this there is no objection, but I submit that the weeding out of the new companies by natural selection will cause no greater inconvenience to the public under provisional order than would arise were they only licensed. Again, the safeguards which have been provided by Parliament and by the conditions the Board of Trade prescribe, amply protect the public against any serious disadvantage arising from incapacity on the part of the undertakers under an order. Directly it is found that the company holding the order is incapable of adequately discharging the obligations arising thereunder, the Board of Trade can revoke the order, and, moreover, grant concurrent orders to other companies. It has been expressly enacted that a provisional order shall confer no monopoly upon the company that holds it, and my company in all their communications with the local authorities of London and the Board of Trade on the subject have intimated their perfect willingness that whatever orders may be granted to them, equal and concurrent powers may, so far as we are concerned, be granted to any other companies over the same areas. I affirm, therefore, with confidence that any disadvantage which may result to the public from the granting of a provisional order to a company not thoroughly able to carry out its work will be temporary in its nature, and slight in comparison with the disadvantage which will ensue if the Board of Trade should adopt the mistaken policy of declining to grant any orders at all until some company has proved its capabilities to demonstration.

"3. On Mr. Hammond's third argument I have no special remark to make, as I think that in most cases it would be correct, subject always to the qualification laid down at the close of this letter.

"4. His fourth reason contains the statement of the fact that two companies gave notice of applying for provisional orders in June last for large areas of the metropolis (his own company did the same in respect of a considerable district in the West End). He goes on to say that if these companies attain their desires, the knowledge and experience of other companies would be excluded.

"Speaking for my own company, I can only assure Mr. Hammond that I have no desire whatever to exclude his or any other company, that I entirely disavow any wish for monopoly, such as he seems to seek for himself, and that all I hope for is a fair field to show what can be done. If the companies he refers to do their work well

the public will get the light more cheaply than if the work were being done by a large number of small companies. If they do not do their work well, other companies can and will come in to compete with them—in either case the public interest is protected.

"5. What is said about the county councils is a matter so entirely within the discretion of the Board of Trade that I merely allude to it to say that I do not think the suggestion a wise one.

"But, sir, there is a point which Mr. Hammond has overlooked, and that of predominating importance—namely, the impossibility of raising the necessary capital under such conditions as he indicates.

"It was the unanimous testimony of every representative of the trade, and of nearly all the other witnesses who were examined on the subject by the Lords' Committee appointed in 1886 to consider the working of the Act of 1882, that the principal cause which retarded the development of electric lighting in England, and caused this country to stand so far behind the United States in that respect, was the unduly short tenure granted to undertakers by a provisional order framed in accordance with the Act of 1882. The justice of this view was recognised by Parliament, which, during last Session, amended the Act by extending the period from 21 to 42 years.

"The effect of this step is shown at once in the revived activity which now exists, and in the fact that numerous provisional orders are being applied for in the metropolis and elsewhere.

"I cannot understand how any gentleman professing to speak as an authority upon the electric lighting question can possibly advocate other views; and yet Mr. Hammond now asks the public to believe that, so far from 21 years being insufficient, the industry may be expected to work satisfactorily under the seven years' tenure afforded by a license. Feeling sure that I shall carry with me the assent of every other representative of the trade, I conclude by asserting that if the Board of Trade should decide not to grant a longer tenure to electric lighting undertakers than is afforded by a license, the distribution of current in London under Parliamentary authority will be checked as effectively for the future as it has been during the past six years.—I am, sir, your obedient servant, "CRAWFORD.

"London Electric Supply Corporation, Limited,
3, Adelphi-terrace, W.C., Jan. 8."

ELECTRICITY: LIGHT AND POWER.

Mr. Holroyd Smith has contributed an article under this title to the "Corporation Societies' Annual," from which the following extracts are taken. The paper is intended to be a popular exposition for the benefit of those unlearned in the subtleties of electrical science. Some of the statements, it will be seen, are rather of an heterodox order.

So rapid has been the development of the application of electricity to useful purposes, and so great are its possibilities for the future, that we may fairly claim to have entered upon the electric age, and the purport of this paper is to recount some of the work that has been achieved, and to explain the "how" and the "why," avoiding, as far as possible, technical expressions, and where they must of necessity occur, giving their meaning.

The explanations are not intended for those "skilled in the art," but are given in the hope that the first principles of the science may be better understood by the general reader.

What electricity is, it is impossible to say; we do not know, nor shall we ever know. Like the questions, "What is life?" "What is matter?" it must remain unanswered; but, though we do not know what it is, we know many things about it, and are constantly learning more. We can produce and measure it, direct and control it, and make it serve a hundred useful ends.

If electro-biology or animal magnetism be excepted, the old-world sages were apparently ignorant of its existence till about 600 years before Christ, when Thales, of Miletus, discovered the peculiar power of acting upon other light substances manifested by a piece of amber after it had been subjected to rapid friction, and, finding this in nothing else, called the action the same name, "electron," the Greek word for amber. We know now that the same property exists in many other substances—sealing wax, for instance; still, the original name has been preserved and become peculiar to this natural force—so much so that some begrudge its original meaning.

It certainly would sound strange, if the word were interpreted, to hear such expressions as the amber telegraph, the amber belt, the amber line, the amber engineer. It may, like "angel," "minister," or "knave," be taken as an example of how the original meaning of a word may be forgotten in its peculiar and recognised use.

The electron of Thales remained a mysterious and unexplainable symptom until well on into the middle ages, and perhaps the first real use of this subtle agent was the mariner's compass.* Little further progress was made until Franklin drew lightning from the clouds.

To a novice it might seem that there was nothing in common between the attractive and repellant action of a piece of rubbed amber, the northward pointing tendency of a steel needle after it had been rubbed with loadstone, and the vivid flash of blinding light that precedes a thunder clap; yet this is so. They are all attributable to the same cause, that mysterious mode of motion which we call electricity. The great world itself may be regarded as a huge dynamo; and there is truth in the saying, "Electricity is life."

The production of electric action by chemical means is a field of research full of interest and instruction; to trace its origin and development, and the many and varied uses to which it has been applied, would occupy more space than is here available. Perhaps the greatest practical use resulting from it is the electric telegraph—

"The wondrous wire of magic power
To flash glad tidings o'er the boundless sea,
And link far nations close in word and thought."

To chemical electricity we owe the knowledge and experience that has enabled scientists to develop its modern form; whilst we were dependent upon chemical action for the production of an electric current, there remained the unsurmountable obstacle to progress—viz., cost. The one ruling question in this commercial world is, "Will it pay?" and whilst we were dependent upon the decomposition of metals in acids for electric energy all attempts to produce light or power failed, except as experiments, because of the expense. Not until that immutable law, the conservation of energy, was formulated and proved, and the principle turned to the study of electric action, was there any real advance. It is therefore obvious that electricity cannot be studied alone, and it is only to be properly understood by being studied in conjunction with the general principles of chemistry, the laws of motion, energy, force, and heat, the fundamental principles of mechanics; in fact, more than a mere surface acquaintance with those subjects usually grouped under the title of natural philosophy is essential.

It is assumed that the construction and operation of an electric battery is well known. To state it broadly, if two plates of different metals—say one copper and one zinc—are placed in a vessel containing an acid solution, and a metallic connection is made between these two plates, a current of electricity passes; this would constitute a primary battery, the metals and chemicals to be used, their compositions, the form of cell in which they are placed, would form an endless subject—their name is legion. Hardly a week passes but somebody invents (or reinvents) a primary battery; and notwithstanding the comparative completeness of the knowledge of electro-chemical action, it is repeatedly being announced to the world that a new primary battery is discovered that won't wear out, that will produce light and power for nothing, because the elements are so changed in the action as to be worth more when finished with than when new. The "how" is kept a profound secret until a company is formed, and after the money has been subscribed it dies a natural death.

It may be stated that a powerful, safe, and economical primary battery cannot be made until metals and acids become as cheap as coal.

A few years ago a notice appeared in the papers that a Frenchman had travelled from Paris with a small box, and conveyed it safely to Glasgow, where a learned professor of deservedly high repute examined it, and astonished the world by stating that it contained stored electricity capable of developing several hundred horse-power if let loose; a meaning and importance has been attached to the professor's words which he could never have intended, and from them a delusion has become fixed in the popular mind that will be difficult to remove—viz., that electricity can be pumped into a bottle and carried about, and it is only necessary to turn a tap to obtain unlimited energy. Let it be here stated that, strictly speaking, there is no such thing as stored electricity, and that the names, "accumulators," "storage batteries," are misnomers. They should be called "secondary" batteries, and their value and utility consists in the fact that, instead of absorbing chemical and mineral elements in the production of electric currents, dynamic force is absorbed—that is, the power of a steam-engine, water-wheel, etc.—and is given out again as electricity. What takes place may be roughly stated thus: A battery consisting of metals and

* The discovery is generally attributed to Flavis, a Neapolitan, but there are grounds for supposing it was brought to Europe from China, by one Paulus Venetus, an Italian.

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acids, preferably lead and dilute sulphuric acid, is taken; the acid has no appreciable effect upon the lead if left alone, but if an electric current is passed through (mark—passed through, not made to stop), it so disturbs the acid and the lead that they get angry with one another, the acid divides itself, one element attacks one lead plate and the other element the other lead plate, and the stronger and the longer the passage of the current the greater the disturbance, the plates become changed, their natural condition is altered, and remains so after the exciting current ceases to flow; but those plates want to resume their natural condition. Join them with a copper wire, they seize the opportunity, and in making friends again reproduce electricity.

There is a limit beyond which these lead plates cannot be excited. When they have reached this limit no useful effect is produced, no matter how much longer you continue to pass a current through them. From this follows the fact that if you want a secondary battery to give off much electricity for some time it must be big and heavy, a fact not sufficiently realised, and one that it would be well for all to remember.

It will be seen from the above that, as "secondary batteries" require a current of electricity to form them, they would be of little commercial value were there no cheaper means of producing electricity than by the employment of primary batteries.

The question may therefore be asked, How, then, can electricity be economical at all? and the simple answer is, because it can be made from coal* without the consumption of metals and acids; and as that answer would naturally elicit the further question, How? an attempt will now be made to give an answer.

Electricity has previously been described "as *a* mode of motion"—the indefinite article is there used because there are other "modes of motion" besides electricity. The very definition itself may seem indefinite, and can only be understood by examining the various manifestations of electric modes of motion. Let us look first to the primary source—viz., heat. Heat, potential or latent, may be regarded as the source, and we may call the sun the great primary battery. Electricity can be produced direct from heat in an apparatus known as a thermopile, and that is the widest and most promising field for further investigation and future development; but inasmuch as we have to remember "will it pay?" they are disregarded here because their present efficiency is too low for them to be of commercial value.

Keeping in view the axiom that heat is the prime source of electricity, let us briefly examine some of its phenomena.

Take an ordinary primary battery with a zinc plate and a copper plate, and couple the terminals by an iron wire. The solution will begin to fume and bubble and boil, and the iron wire will become hot. The passage of the electric current manifests itself by the production of heat. If the battery is strong enough, the wire will become red, then white-hot, and fuse away.

This is the principle of all electric light—viz., the passage of an electric current producing heat. If the battery and the wire were well arranged, little heat would be produced in the battery and intense heat in the wire. It is popularly supposed that the electric light is cold. This is an error; the coldest-looking light is the hottest. It is the very intensity of the heat of the arc lamp that produces the blue-white glare. There is nothing hotter. That small bead of light between the two points of the carbon rods is eight times hotter than molten iron. The little wiry-looking thread in the glow lamp gives out light because of the heat produced in it by the passage of electricity. Were it not in the glass globe, from which all the air has practically been exhausted, it would be instantly burnt away. Without pursuing this investigation further, we see that electricity produces heat, and that heat can be made to produce electricity.

Let us now look for manifestations of electricity other than heat (we can find none without).

If, instead of coupling the terminals of the battery by a piece of iron wire, we had taken a piece of copper wire covered with cotton or silk (for anything that is a bad conductor of heat is a bad conductor of electricity), and had wound it round a bar of iron, we should find that the passage of a current of electricity round and round the iron would make it magnetic—that is, capable of attracting and holding other pieces of iron. If we wind another piece of wire round the same bar, but instead of coupling its ends to the battery we couple them to an instrument so constructed that it will indicate when a current is passing, then if we continue lifting and replacing the zinc plate in and out of the solution, we shall find that the instrument indicates the passage of electricity through the wire that has no connection with the battery at all, but simply wound alongside the battery wire. Again, suppose we coil the battery wire round a paper tube and allow the current to continue to flow through it, and wind the instrument wire round an iron bar small enough to pass into the paper tube, and drop it in and pull it out, we shall find that each time we do so the instrument will indicate the passage of a current.

Take a plain bar of iron, and slowly insert one end into the coil, it will be immediately sucked in and held there as long as the battery current flows through the wire. If the bar were steel instead of iron, and were allowed to be sucked in at one end of the coil and forcibly withdrawn at the other or opposite end, and the process repeated a few times, the steel bar would not only be a magnet whilst in the coil, but would remain one after it was removed, and be able to attract and hold pieces of iron, although there was no battery sending a current of electricity round it.

If, now, we took the steel magnet, and the bar of soft iron previously mentioned, with the coil of copper wire wound round it, having its ends attached to the indicating instrument, and approached one end near enough to the steel magnet to feel the pull and suddenly withdrew it—that is, waved it to and fro past the end without allowing it to touch—we should find that the instrument would indicate the passage of an electric current through the copper wire, and the nearer it came and the faster it moved the stronger would be the indication.

The above may seem simple experiments and not of much practical use, but they are the A B C of electrical engineering, and if fully mastered and realised will be found to be the foundation upon which much modern work is built; but there is one other simple experiment which has been attended with such important results that it deserves especial notice. All iron is slightly magnetic, all iron will become strongly magnetic if a current of electricity passes round it; so instead of using the steel permanent magnet, take two bars of iron, each with a coil wound round it, join one end of each coil by a flexible wire and connect the other ends to the instrument and repeat the waving process, but more rapidly, and it will be found that the instrument again indicates a current. The slight magnetism in the iron has caused a slight current in the wire, and the slight current in the wire passing round the stationary bar increases the magnetism of the iron, the increased magnetism strengthens the current, and so one acts upon the other. The stronger the magnetism the stronger the current, and the stronger the current the stronger the magnetism; and if these went on increasing, the force would become so strong as to burn up the copper wire: this has been done.

The foregoing experiments have been given in their simplest condition, without describing what constitutes the best form of magnets, or how copper discs or coils of wire can in some cases be substituted for the iron bars, or how and why the copper wire has to be insulated, etc.

They are, however, sufficient to show some of the essential facts which are at the service of all who will learn how to use them—the hammer, the vice, the file, and the chisel of the electrical workshop—and it only needs the spirit of adaptation to render them useful. Just one example. It would evidently be fatiguing to continue waving the iron bar with a coil round it to and fro in front of a magnet, and it would naturally suggest itself to a mechanical mind that this bar, and others like it, could be attached to the surface of a wheel, and by rapidly rotating the wheel they could be rapidly made to traverse across the face of the magnet, or, to use a technical expression, made to cut the lines of force in the magnetic field. And, further, when by this wheel a small quantity of electricity is obtained, say sufficient to light one small lamp, it will be easily seen that by making a larger machine and employing a steam-engine to turn it, large quantities of electricity can be obtained without using any battery at all; and, it may be asked, "Is not electricity the transformation of transmitted energy?"

Some other facts are necessary to be known and understood before we can attempt to make practical use of those already given. Perhaps that which is manifest in the mariner's compass is the most important—viz., the north-seeking tendency of one end, and the south-seeking tendency of the other.

It does not follow from this that all "dynamos" or electric instruments must be so placed relative to the earth's axis as to accommodate to the north and south, but another result of this tendency is of the highest importance—namely, that the N. (or north) pole of one magnet attracts the S. (or south) pole of another; but the N. pole repels another N. pole, likewise an S. pole repels another S. pole. This may be shortly expressed by saying opposite poles attract and similar poles repel each other.

If, therefore, two magnets are taken and are held a distance apart, with opposite poles facing each other, and a plain iron bar free to swing upon a pivot be placed between them, and at right angles to them, it will at once swing until it lies in a line with the magnets, and it does not matter which end of the plain iron bar turns to the north or south of the magnet; but if the plain iron bar be removed and a steel bar that has been made into a permanent magnet be substituted, and it be so held that the north of the steel magnet faces the north of the main magnet, if released, it at once swings round and points to south, whilst the end south has also swung to north, and if the magnets are large it will require considerable force to twist them away.

Now, if the order were reversed, and an electromagnet were used in the middle to swing round between the poles of a permanent magnet and it be rapidly turned by any convenient means, it would constitute a magneto-electric machine. The revolving part is technically known as the armature.

* The latent energy of a pound of coal is 12 times greater than the latent energy of a pound of zinc, whilst a pound of zinc costs 20 times as much as a pound of coal.

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It would be entering too much into detail to explain how the ends of the wires would have to be coupled and compensation made for the fact of rotation; sufficient to say that this is accomplished, and the parts fulfilling the object are called "commutators" and "brushes."

Just go a step further. Remove the stationary steel magnet, and in its place put bars of soft iron with wire wound round it, and, taking advantage of the commutators and brushes, allow the current produced by the revolutions of the armature to flow round the wires of the stationary magnets as well as going to the outside work (lamps, etc.), then the machine becomes an electric generator, now generally known as a "dynamo."

From what has been said before it will be seen that a machine built on this principle has only to be made to revolve rapidly to produce electric currents, and, what is equally important, it is only necessary to allow an electric current to flow into the machine to cause it to revolve and make it into an electric motor; why this is needs a little further explanation (although the underlying facts have been previously stated).

(*To be continued.*)

COMPANIES' MEETINGS.

PILSEN, JOEL, AND GENERAL ELECTRIC LIGHT COMPANY.

An extraordinary general meeting of the Pilsen, Joel, and General Electric Light Company, Limited, was held on January 4 at the City Terminus Hotel to consider a resolution voting £100 each to Messrs. H. W. Scriven and G. L. Whately in respect of their services as Directors of the Company from December 11, 1886, to March 13, 1888, and also the confirmation of the resolutions passed at the meeting on the 14th ult., (1) for winding up the Company voluntarily; and (2) for appointing Mr. George Shead and Mr. W. H. Trentham joint liquidators.

Sir R. W. Rawson, who presided, stated that when at a former meeting it was found that, through an oversight (the nominal value of the shares having been reduced), Mr. Sciiven and Mr. Whately had ceased to be qualified, they at once refunded the money they had received as Directors. He expressed a hope at the time that the amount in question would be returned to them, and their largest shareholder had now proposed that that should be done.

Mr. Gwynne then moved, and the **Chairman** seconded, a resolution voting the payment of the sum named to Mr. Scriven and Mr. Whately.

Mr. Fyfe and other shareholders objected on various grounds to the payment, and the Directors were charged with gross mismanagement.

On a show of hands being taken, the resolution was declared lost—five voting for it and six against it. A poll was demanded, and at once taken, when it was announced by the scrutineer that the number of votes recorded against the motion was 1,010, and in favour of it 8,102.

The **Chairman** then duly declared the resolution carried. He afterwards proposed the confirmation of the resolution for winding up the Company voluntarily.

Mr. Hutton moved and **Mr. Blecklehurst** seconded an amendment adding to the resolution the words "under the supervision of the Court."

The **Chairman** stated that the alteration ought to have been made at the first meeting, and that the resolution must now be either rejected or carried. He then put the motion, and declared it carried by nine to four.

The resolution confirming the appointment as liquidators of Mr. Shead and Mr. Trentham was afterwards agreed to by seven to four.

MAXIM-WESTON ELECTRIC COMPANY.

An extraordinary general meeting of the Maxim-Weston Electric Company, Limited, was held on January 7 at the Cannon-street Hotel, for the purpose of confirming the resolutions passed at the extraordinary general meeting held on December 21 last. Mr. John Marks occupied the chair.

Mr. Samuel J. Boyce (the secretary) read the notice convening the meeting.

The **Chairman:** Gentlemen, in moving the confirmation of the resolution just read by the Secretary, I will draw your attention to one clause in the agreement which was read fully at the last meeting —every word was read fully at the last meeting, therefore I presume you know its contents. One clause provides that the new company have the power, by giving notice to the liquidators, to terminate the agreement if dissentient shareholders, or shareholders holding 30,000 shares, dissent from the reconstruction scheme. Well, now we know that great efforts are being made in certain quarters to induce shareholders to dissent from the reconstruction scheme, and those efforts are being made from interested motives. Mr. Abrahams at the last meeting told us that he represented shareholders holding 30,000 shares, and he should certainly dissent from the scheme. If shareholders holding 30,000 shares only dissent, I do not think that would be a bar to the new company carrying out this agreement with the liquidators; but if a very large number of shareholders dissent, I think then the new company would be justified in not carrying out the agreement, because, to satisfy the gentlemen who dissented, the money of those who took up new shares would have to be applied, and that would not be fair. I merely make these remarks to point out to you it is contrary to your interest to dissent from the scheme. It is all very well for Mr. Abrahams to tell us the liquidators will give 2s. a share to each dissentient. That is held out for the purpose of inducing you to dissent. We have a very different opinion. I think if they get 3d. or 4d. a share they will be lucky. Therefore don't be deluded into the belief you will get 2s. a share by dissenting. It is merely placed before you for the purpose of damaging the Company. I am sorry Mr. Abrahams is not heie. I wanted to tell him, as representative of Mr. Hugh Watt, even if the scheme does not go through—and I cannot believe the shareholders will be so blind to their own interest as not to carry the scheme out—whatever is the result, the matters between this Company and Mr. Watt, even if this Company falls into the hands of the liquidators to be dealt with finally —the matters at issue between Mr. Watt and the Company will be carried out by the liquidators just as if the new company was formed. I now formally move the confirmation of the following resolutions—viz.: "(1) That the liquidators of the Company be, and they are hereby, authorised to consent to the registration of a new company, to be named the Maxim-Weston Electric Company, Limited, with a memorandum and articles of association which have already been prepared with the approval of the Directors of this Company. (2) That the draft agreement submitted to this meeting, and expressed to be made between this Company and its liquidators of the one part, and the Maxim-Weston Electric Company, Limited, of the other part, be, and the same is hereby approved, and that the said liquidators be, and they are hereby authorised pursuant to Section 161 of the Companies Act, 1862, to enter into an agreement with such new company (when incorporated) in the terms of the said draft, and to carry the same into effect with such, if any, modifications as they think expedient." The agreement is here and open to the inspection of anyone who wishes to see it, and with your permission I will take it as read. It is a long document, and any gentleman who wishes to see it can do so.

Mr. Swaby: I beg to second the motion, and I think I ought to say a few words. Several shareholders have begged that, if the scheme failed, we would endeavour in other ways to carry the company through. They are poor shareholders, and ask us to do all in our power. I must say the Board has worked hard in your interest, and in your interest alone.

Mr. Klenck: I may point out that this is our final scheme, and if you do not accept it the consequence will be the Company will go into liquidation, and then you know the result—the selling of our patents and machinery, and everything we possess, and that will only give you a very small distribution. I think our Chairman has taken a rather gloomy view of the situation. A threat is one thing, and a fact is another. We hold these proxies from the shareholders who have sent us their support. We have not a single opposition in the office, and I think that ought to be known to the shareholders generally, so that they may not follow in the footsteps of those who have interested motives in asking them to dissent from the scheme. If you are wise you will come into the scheme, and we shall be able in a very short time to put the Maxim-Weston on a sound commercial basis, a position we have not occupied for some considerable time in the past, so that we may be able to take orders and execute them for the benefit of the shareholders.

The resolution was then put and carried.

The **Chairman:** The forms of application for shares will be sent out in due course to each shareholder, and, as Mr. Klenck says, I hope we shall find the shareholders support us in the same manner as they have done in sending in their proxies.

A **Shareholder:** I would suggest that when the forms are sent out, a report of this meeting should be sent in order to show shareholders what their position will be if they dissent. Probably many may dissent, thinking they will get 2s. a share. They should understand that they will more probably get 2d.

The **Chairman:** I think that this is a very good suggestion, to send out a *résumé* of what has taken place, and that we will do.

Mr. Klenck stated that the number of shares held by the dissentients amounted altogether only to 50 shares.

The proceedings then terminated.

METROPOLITAN ELECTRIC SUPPLY COMPANY.

An extraordinary general meeting of the Metropolitan Electric Supply Company, Limited, was held on Tuesday, for the purpose of considering resolutions in accordance with the requirements of the Committee of the Stock Exchange altering the articles of association of the Company. Alderman Sir R. N. Fowler, M.P., occupied the chair.

Mr. E. Cunliffe-Owen (the Secretary) having read the notice convening the meeting,

The **Chairman** said: These alterations were required by the Committee of the Stock Exchange. They were merely for the purpose of carrying out the stipulations of the Stock Exchange, and he would ask Mr. Burt to explain their purport.

Mr. Burt: Article 26 is the first of the proposed alterations. The article says: "The share qualification of a Director shall consist of his being a registered holder of 200 shares. A Director may not act before acquiring his qualification." The Stock Exchange require these latter words to be struck out. The point is of no importance whatever in this Company, because the Directors have long since acquired their qualification. Article 45 is a limitation of the powers of borrowing of the Company, which is also one of the new requirements of the Stock Exchange. Probably shareholders will think it reasonable. It is a recent requirement, by which in all cases they ask that powers of borrowing should be limited to some extent by the articles of association. Article 45 was drawn in the old form without restriction, and it is proposed to add the words which are, in fact, a limitation to the amount of the share capital at the time being of the Company. Article

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102 is also one which is a modern requirement of the committee. It stood thus: "A Director shall not be appointed auditor"; they ask it shall be altered: "No Director or other officer of the Company shall be appointed auditor." Of course, there was no intention of appointing anyone who is an officer. Article 119 restricts the lien on the shares to those which are fully paid. In Article 121 there is an alteration which provides that the transfer of shares shall be in the usual common form. In Article 123 they desire to insert the words "not fully paid up." "Transfer of shares shall not be made to any person who shall not be approved by the Board." The addition is, "not fully paid up"; so that a transfer may be made to any person if the shares are fully paid up. If they are not fully paid up, it is necessary the board should have discretion, otherwise, if any company were in difficulties, and there was a sum unpaid on the shares, the holder of the shares might transfer them to a man of straw to escape his liability. In Article 130, which says, "Every original shareholder shall, on the original issue of the shares, be entitled to one certificate for each of his shares granted to him, but in every other case 1s. shall be paid," they require some alteration which is not of the slightest importance. In Article 155 the words come in again about not being fully paid up, and that applies to the lien also. It appears to be pretty much the same as in the previous clause. These are the only alterations. I think it will be convenient to take the resolutions *en bloc*.

The **Chairman:** Then I beg to move the following resolutions: "That the articles of association of the Company be altered as follows: Article 26—By striking out the words 'A Director may act before acquiring his qualification.' Article 45—By adding at the end of this article the words 'Provided that the power of borrowing and raising money, and of making and issuing mortgages, or debentures, or debenture stock, obligations or other securities, shall not at any time, without the sanction of a general meeting, be exercised to such an extent that the total amount of principal money borrowed, raised, or secured shall exceed the nominal amount of the share capital for the time being; but this restriction shall not oblige any person taking any mortgage, or debenture, or debenture stock, obligation, or other security of the Company, to inquire whether there has been any such excess, or affect the validity of any such security in the hands of a bona fide holder, nor interfere with the power of the Directors to make and enforce calls.' Article 102—By striking out the words, 'A Director shall not be appointed auditor,' and inserting in lieu thereof the words, 'No Director or other officer of the Company shall be appointed auditor.' Article 119—By inserting after the word, 'shares' the words, 'not fully paid.' Article 121—By inserting after the word 'writing,' the words 'which may be in the usual common form.' Article 123—By inserting after the word 'share' the words 'not fully paid up.' Article 130—By striking out all the words except the words 'every shareholder shall be entitled to one certificate for his shares gratis, but in every other case one shilling shall, where the Board think fit, be paid to the Company for every certificate.' Article 155—By inserting after the word 'shares,' in line 2, the words 'not fully paid up.'"

Sir James Anderson seconded the motion, which was carried unanimously.

A vote of thanks to the Chairman and Directors then terminated the proceedings.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts for the past week amounted to £3,755.

Direct Spanish Telegraph Company.—The estimated receipts for December were £1,908 against £2,004.

Great Northern Telegraph Company.—The receipts of this Company for the month of December amounted to £22,000.

West Coast of America Telegraph Company.—The receipts for the month of December amounted to £4,475.

Eastern Telegraph Company.—The receipts of this Company for December were £59,834, as against £57,703 for the same period of 1887, or an increase of £2,131.

Eastern Extension Telegraph Company.—The receipts of this Company for the month of December were £38,699, as against £38,908 for the same period of 1887.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting the "fifth" payable to the London Platino-Brazilian Company, were £3,228.

United River Plate Telephone Company, Limited.—This Company have declared an interim dividend, for the half-year ending September 30 last, of 3 per cent. (being 3s. per share), tax free, payable on and after the 15th inst.

Edison and Swan United Electric Light Company, Limited. Owing to Victoria-street, Westminster, having been renumbered, in future the address of the Edison and Swan United Electric Light Company will be 100, Victoria-street.

Companies of the Month.—The following electrical companies have been registered during the month:—

British Electric Tramways and General Syndicate, £5 shares £10,000
Electropathic and Turkish Baths, £1 shares 10,000

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of the Cuba Submarine Telegraph Company during September was 4,323, estimated to produce £3,500, against 3,925 messages, producing £3,373. The receipts for September, estimated at £2,700, realised £2,774. It is announced that the offices of the Company have been removed to 58, Old Broad-street, E.C.

NEW COMPANIES REGISTERED.

E. Page and Company, Limited.—Registered by Crossman and Pritchard, 16, Theobald's-road, Gray's-inn, London, W.C. Capital £30,000 divided into 30,000 shares of £1 each. Object: to carry on the business of an agricultural, mechanical marine, electrical engineer, and of an iron and brassfounder and ironmonger in all its branches. To acquire the business now carried on by James Woodward Hill, trading as E. Page and Company, at Bedford, in the county of Bedford, and to carry on the same in all its branches. The first subscribers are:

	Shares.
L. Hely, 40, Montpelier-street, Knightsbridge, London, S.W.	50
B. H. C. Caxton, Margett's-road, Kempston	50
F. H. Hill, 22, Kimbolton-road, Bedford	50
F. Fisher, 14, Castle-road, Bedford	50
E. D. Rabbitt, 21, Grove-place, Bedford	50
J. H. Darlow, 1, Horne-lane, Bedford	50
J. W. Hill, 22, Kimbolton-road, Bedford	29,700

There shall not be less than four nor more than six Directors of the Company, and no person shall be a Director unless he holds at least 50 shares in the capital of the Company. The first Directors shall be James W. Hill, B. H. Claxton, E. D. Rabbitt, J. H. Darlow, and E. Fisher. The first Directors shall be paid the sum of £50 per annum each, with an additional sum of £50 to the Chairman.

PROVISIONAL PATENTS, 1889.

JANUARY 1.

30. **Improvements relating to electric telegraphy.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

46. **An improved atmospheric thermo electric generator.** William Scarlett de Lisle Roberts and James Smith Mollison, 6, Bream's-buildings, Chancery-lane, London, W.C. (Complete specification.)

JANUARY 2.

85. **Improvements in dynamo electric machines.** Arcadius Poleschko, 24, Southampton-buildings, London, W.C.

JANUARY 3.

112. **A railway distant electric flashing signal.** James Woods and Henry William Hatfield, 54, Winchester-street, Caledonian-road, N.

118. **Improvements in electric brakes for railway trains.** Watson Playtor Widdifield and Alexander Hamilton Bowman, New Bridge-street, Manchester. (Complete specification.)

126. **An improvement in or relating to dynamos.** Gilbert Bettley Lückhoff, 166, Fleet-street, London.

135. **Improvements in the arrangements for lighting and, or, braking railway vehicles electrically.** Illius Augustus Timmis, 2, Great George-street, Westminster, S.W.

JANUARY 4.

179. **Improvement in the use of incandescent electric lights.** Charles Wells, 22, Southampton-buildings, Chancery-lane, W.C., Middlesex.

189. **Improvements in armature winding for dynamoelectric machines.** Walter Harris Knight, 23, Southampton-buildings, Middlesex. (Complete specification.) (Date applied for under Section 103 of the Patents, &c., Act, 1883, 6th June, 1888, being date of application in the United States.)

JANUARY 5.

238. **Improvements in alternate current dynamo electric machines.** John Dixon Gibbs and Emile Fesquet, 47 Lincoln's-inn-fields, London.

SPECIFICATIONS PUBLISHED.

1888.

242. **Electrical measuring instruments.** Davies. 8d.
366. **Electric arc lamps.** Abel. (Siemens and Halske.) 8d.
1525. **Distributing electricity.** Solignac. 8d.
2449. **Electric railways.** Allen. 8d.
13,529. **Electric meters.** Reckenzaun. 8d.
14,919. **Electrical brake, &c.** Hutchinson. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	4¼
12 Feb.	2/0	— fully paid	5	5¼
14 Nov.	0/4½	Con Telephone & Main ...	1	[illegible]
27 July	10/0	India Rubber, G. P. & Tel.	10	19[illegible]
16 Mar.	5%	Maxim Weston	1	[illegible]
30 May	2½%	Oriental Telephone	11	[illegible]
26 April	4/0	Reuter's	8	7¼
......	...	Swan United	3½	2[illegible]
12 July	12/0	Telegraph Construction ...	12	41[illegible]
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	14

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NOTES.

"Electric Power."—A new journal specially devoted to electric motor work of all kinds has just been started in New York, under the title of *Electric Power.*

Removal.—Mr. A. A. Campbell Swinton has removed his offices to 66, Victoria-street, Westminster, where all communications should now be addressed to him.

The Heisler System.—There are 40 towns using 16,465 lamps of 30 c.p. on the Heisler long-distance incandescent system in the States at the present time.

Obituary.—The death is announced of Sir William O'Shaughnessy Brooke, late Director-General of Telegraphs in India, at Southsea, in the 80th year of his age.

The Julien System.—The three Julien cars on the New York line have run 125 car-days, giving a run of a total of 3,913 miles, and carrying 35,066 passengers.

Brockie-Pell Arc Lamps.—Messrs. Johnson and Phillips report a sale of 600 Brockie-Pell arc lamps during last year. The lamps have gone to all parts of the world.

City Lighting.—A resolution passed at the Aldgate wardmote in favour of electric lighting has been referred to the Streets Committee of the Commissioners of Sewers.

Society of Arts.—A paper will be read at the Society of Arts on Wednesday next, January 23, at 8 p.m., on "Electric Meters for Central Stations," by Prof. George Forbes, F.R.S.E. Mr. W. H. Preece, F.R.S., will preside.

Delaney's Cable Apparatus.—Mr. P. B. Delaney has received advices to the effect that the German Government has purchased a set of his cable instruments for use on their long underground circuits, upon which the system has been undergoing trial for several months.

The Electric Light at Leamington.—The Leamington Town Council has resolved to give the Midland Electric Light Company 12 months' notice to determine a contract for lighting the streets of Leamington by electricity, on the ground that it had been a failure.

Electric Sugar.—Warrants for the apprehension of the proprietors of the electric sugar fraud cannot be obtained in America. So reluctant are the shareholders to have their connection with the company brought before the public, that they have decided not to take action.

Bank Lighting.—We are glad to see electric lighting in the City banks is becoming quite general. The London Joint Stock Bank, one of the most conservative of City concerns, which has long held out against the innovation, has at last given in its adherence, and is to be lighted by electricity.

Institution of Electrical Engineers.—The next meeting of the institution will take place at 25, Great George-street, Westminster, on Thursday, January 24, at 8 p.m., when Prof. Andrew Jamieson, F.R.S.E., will read a paper on "The Insulation Resistance of Electric Light Installations."

Theatre Burnt.—Another theatre is burnt, due to the use of gas. On the 29th December the municipal theatre of Novgorod was burnt to the ground, the fire resulting from an explosion of gas. Two persons were killed, and more than thirty injured. Electric light will probably be now installed.

The Julien-Sellon Controversy.—The assignees of Sellon, the Electric Accumulator Company of New York, have insisted that the addition of mercury to the antimony and lead in the plates did not constitute a new invention, but the advantage of the triple alloy in decreasing resistance has been acknowledged by the primary examiner as a distinct invention, and the patent is upheld.

Rome.—The Baudot duplex apparatus has been working for three months on the line between Rome and Turin, before worked with Wheatstone instruments. The Baudot quadruplex will be installed during January on the Rome-Milan line. The chamber of representatives and the senate at Rome are lighted with Edison lamps supplied from the dynamos run by the Rome Gas Company.

Holborn.—At the last meeting of the Holborn Vestry a resolution was carried that the Board do present a petition against and oppose the London Central Subway Railway Bill. A letter was received from the London Electric Supply Corporation, asking the Board's assent to the granting of a provisional order. The communication was referred to the Committee of Works for consideration and report.

Fair Play to Barnet.—We have got to hear that the *Electrician* sent down a special commissioner to Barnet to find out all about the electric light, and report upon the lamps, cut-outs, and general installation. The result happened to be favourable, and the report promptly went into the waste paper basket, a remark simply appearing in the year's summary that the light is not yet satisfactory. How's this, Mr. Editor?

Electric Mining.—By the last mail the Humboldt Electric Power and Mining Company received the survey of the water site, with particulars of fall and quantity of water, both of which are up to estimate, and the distance from the mines is rather less than anticipated. Negotiations are now in progress for the erection of the necessary machinery; the first installation of electric power will be made to the present Esmeralda mill.

Desiderata.—A gold medal has been offered by the Société Industrielle d'Amiens, France, among other things, for the following: A dynamometer of more convenient installation than the Prony brake; a cheap and simple dynamometer capable of measuring the power absorbed by a belt-driven or geared machine tool; apparatus for purifying boiler feed water: the best arrangement for electrically lighting works at less cost than by gas.

Galway.—Tenders are invited by the Galway Town Improvement Committee for the public lighting of the town by gas, electricity, or other approved illuminant. It is expected that electricity will be approved. Specifications can be obtained of Mr. J. Redington, Town Commissioners' Office, Galway. Sealed tenders to be sent in by 7th March. Galway at present is not half lighted, and it ought to be known before tendering whether the specification provides for sufficient light.

Magnetism and Electromotive Force of Batteries.—*L'Electricien* of 22nd December has a note upon the effect of powerful magnetic fields on the E.M.F. of batteries. Figures are given showing the variation (we suppose an increase) in E.M.F. of from 0·0008 volts with a field of 2,000 C.G.S. units to 0·0680 with a field of 19,700 units. A platinum-iron-chromic acid battery was used. The effects are feeble, and delicate instruments are necessary to detect them.

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Austrian Patents.—In consequence of a recent decision of the Austrian Patent Department, the grant of Austrian patents can henceforth be delayed by applying for it. This alteration in the practice has been adopted with a view to offer the applicants for Austrian patents who have also applied for U.S. patents the utmost security with reference to the uncurtailed duration of the latter, as the grant of the Austrian patent can in such cases be delayed until after the grant of the U.S. patent.

Automatic Supply.—We alluded lately to the possible use in the future for an automatic box arrangement for electric light supply, similar to that proposed for extending the supply of gas to small customers. We notice that a patent has been taken out for such an apparatus by D. H. Davies, of Leeds, and J. M. Tourtel, of Westminster, specially designed for use in railway carriages, but applicable also to other purposes, whereby a passenger or person can obtain an electric light for a given length of time by inserting a coin, and can continue the light by successively contributing coins.

Oil Filter.—An oil filter has been brought out for long running machinery, and is in use in electric light installations for cleaning the used oil. The outer vessel is of glass, through which the action can be inspected; several layers of filtering material—woollen cloths, etc.—are arranged in this, the last layer being at the top. The filter is partly filled with water, and the oil being admitted at the bottom, rises upwards, while the metallic particles fall to the bottom, the drop fall of the oil being broken by the capillary action of the wool, and the clear oil is drawn off at the top.

Electric Locomotive.—An electrical locomotive is building at the New York Locomotive Works, in Rome, N.Y. The engine, says the New York *Electrical Review*, is to be operated solely by electricity, and is designed to run on all roads where steam is now used. It will weigh 15 tons, and when turned out of the shop will be an exact counterpart of an ordinary locomotive, though considerably smaller and lighter. When finished, an electrician from New York will take charge of it, and place in it the electrical apparatus to be used as a motive power. The inventor is W. H. Darling, of Brooklyn.

House of Commons.—The electric light will soon be fitted throughout the House of Commons. Parts of the building have been lighted for some time, including the division lobbies and upper corridors, library, reading-room, tearoom, smokeroom, and a few other rooms, but when Parliament reassembles the cloakrooms, entrance lobbies, and main staircase, etc., will also be lighted. It is understood that the complete adoption of electric light in the House is shortly to follow, and the committee-rooms, the corridors, waiting-halls, and members' lobby, now lighted either by oil or gas, will all be fitted with electric light.

Sulphur as Insulation.—In connection with the high-tension work in progress at Deptford, where it is well known that compounds of sulphur are used for insulation, some experiments of Mr. James Monckman, D.Sc., on the electrical properties of this substance will be interesting. The specific resistance of sulphur was found to be very high, reaching $5{\cdot}6 \times 10^5$ ohms at 440 deg.C., its boiling temperature. At 260deg.C. it is 5×10^8 ohms, these figures referring to chemically pure sulphur. The commercial material has a much smaller resistance, being only $1{\cdot}6 \times 10^5$ ohms at 440deg.C., and 5×10^3 ohms at 125deg.C., its melting point.

The Tesla Motor.—The first exhibition in public of the celebrated Tesla motor took place at the meeting of the City and Guilds Old Students' Association on Wednesday last on the occasion of Mr. Snell's paper, reported elsewhere. The motor in question is a small model, eight or nine inches square, and has never run yet in this country at least, the necessary alternating currents not being obtainable. In has four terminals, and no brushes whatever, the armature simply turning in the varying magnetic field. This specimen was to have been exhibited by Prof. Ayrton at the Bath meeting of the British Association, but did not arrive in time.

Edison Philadelphia Station.—The new Edison electric light station in Philadelphia will soon be in operation. It is six stories high, and was erected at a cost of £30,000. On the first floor will be placed 20 engines of 250 h.p. each. On the second floor there will be 40 dynamos, with a total capacity of 60,000 lights. The third floor will be used for the workshop; the fourth floor for 10 boilers of 500 h.p. each. The fifth floor will accommodate 1,000 tons of coal, which will be fed by pipes to the furnace under each boiler. The sixth floor will be devoted to the general offices of the company. The total cost will be £200,000, including 84 miles of underground cable.

Electric Duel.—The discussion about the danger of alternate current has reached an amusing pitch in New York. Harold P. Brown has challenged Westinghouse to an electric duel; Harold P. to be connected to a direct current machine and Westinghouse to an alternate. Fighting to commence at 100 volts, raising by 50 volts, and maintained for five seconds. Harold P. to take first shock every time till one of the duellists has had enough and publicly admits his error. He warns Westinghouse, however, that death has occurred in his experiments with alternate currents at 160 volts maintained for five seconds, and that men have been killed on the low-tension Jablochkoff alternating system.

New Metropolitan Central Station.—The first contract for a central station having gone to Westinghouse, considerable interest has been aroused as to who will receive the contract to carry out the second installation for the Metropolitan Electric Light Company. Detailed and finished specifications were prepared and sent out, and the tenders from English firms have been under consideration some time. We hear that the contract has been finally awarded to Messrs. Johnson and Phillips for the erection of a central station, the dynamos to be employed being the new alternating machines of Mr. Gisbert Kapp, who has lately made arrangements to join the firm as consulting electrical engineer.

Anglo-Belgian Telegraphs.—A decision of importance to persons telegraphing to the Continent has been arrived at by the Anglo-Belgian Telegraph Convention. The concession of the Submarine Telegraph Company has expired, and no further concession is to be granted to private persons. The two existing cables between Middelkerke and Ramsgate, and La Panne and Dover are to be taken over by the two countries, and, if necessary, three new cables, each with four conducting wires, are to be laid. The rate for ordinary telegrams is to be 2d., or 20 centimes, per word; and the returns are to be divided at the rate of 11·25 centimes for England, and 8·75 centimes for Belgium. The sums received for transit telegrams are to be divided equally.

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American Progress.—While England is waking up a little in central station matters, it may be interesting to note one week's progress in the States, as chronicled in one column of the last number of the *Electrical World*: Barre, Vermont, 35 arcs; San Antonio, Texas, 1,000 incandescents; Jackson, Mich., 70 arcs; North Topeka, Kan., 50 arcs and 600 incandescents; Cincinnati, 1,500 arcs; Hoosac, 1,950 arcs; Indianopolis, 500 arcs; Annapolis, 200 arcs and 3,000 incandescents; Brooklyn, 200 more arcs; Charlotte, North Carolina, 2,000 incandescents; Bay Shore, 30 arcs; New York, new Edison plant, Thirty-ninth-street, two stations for 28 dynamos each begun running with two dynamos to start, rest to follow; besides others, numbers not given.

Extension of Telephony.—On the 9th inst. a special meeting of the Western Counties and South Wales Telephone Company was held at Bristol, to authorise the raising of additional capital consequent on the extraordinary extension of the company's system. Mr. Charles Nash, chairman of the directors, said that in order to meet the demand for telephonic communication over the company's system, the directors recommended the creation of 50,000 5 per cent. debentures, 30,000 being offered immediately. The telephone, he added, was gradually growing in favour, and in Portsmouth, Plymouth, Cardiff, Swansea, and Bath the company had several hundred subscribers. Before the end of the year the telephone would be opened between London, Birmingham, and Bristol.

The Engine-room Telegraph.—The Central News states that the Admiralty have definitely adopted into the service the engine-room telegraph and electric signalling system known as Willis' patent, which will replace the mechanical system now in use. The Willis' arrangement was subjected to the roughest practical test before its adoption, both on land and at sea, and was the only invention which met every requirement and successfully stood every condition of service. All new ships and vessels refitted will be supplied with these instruments. In appearance and in handling the new electric telegraph is much the same as the old mechanical system. Its greatest advantage is that signals can be acknowledged as understood, a point which greatly tends to reduction of accidents at sea.

Colbere's Microphone.—A new form of microphone with some points of interest has been devised by P. Colbere, of Berlin. In this a movable box on a support is almost filled with carbon disposed in the form of a receptacle and filled with mercury (or amalgam), which itself is covered with a layer of granulated carbon, on which rests the diaphragm. This diaphragm consists of a very thin plate of carbon, fixed by the edge between the two insulating rings. The plate is connected to one terminal, and the granulated carbon communicates with the other terminal of the battery. By reason of its extreme mobility, the mercury obeys the slightest oscillations of the diaphragm, and the transmission of sound by means of this microphone is said to be extremely good, and distinctly heard even at some distance.

St. James's Hall.—The installation at the St. James's Hall, which was supposed to be one of the finest installations on the Grosvenor circuit, has gone through sundry vicissitudes. Originally wired by Messrs. Thompson and Ritchie, it has passed under the hands of two or three other contractors for more or less tinkering—result, constant dissatisfaction. The management, seeing that this is a matter which concerns the public, have now given the work to be carried out, without specified contract, to the Acme Electric Works, under the direction of Mr. Arthur Cockburn, to rewire and thoroughly reorganise. Slate switches are to be fitted throughout, and Cockurn's patent fuses alone are to be used. The circuits are redistributed, and all the fuses for the hall are arranged on one slate base in the roof, where they can be easily replaced, instead of fuses to every group. New fittings are also to be fixed.

Electro-Harmonic Society.—The next smoking concert of this society will be held at the St. James' Hall Restaurant on Friday, January 25, when the following programme will be carried out: Part 1: Trio, "Wine! the Magician thou art" (Balfe), Mr. Arthur Thompson, Mr. R. E. Miles, and Mr. Alfred Moore; song, "I seek for thee in every flower" (Ganz), Mr. Edward Dalzell; new song, "Pour forth the Wine" (Hamish M'Cunn), Mr. Alfred Moore; solo flute, "Scotch Fantasia" (Sannelet), Mr. John Radcliff; song, "In a Distant Land" (Taubert), Mr. Arthur Thompson; song (by request), "The Raft" (Pinsuti), Mr. R. E. Miles; humorous song, Mr. J. Kift. Part 2: Part song, "Slumber, Dearest" (Mendelssohn); new song, "Fame, the Fiddler" (Molloy), Mr. Alfred Moore; song, "The Death of Nelson" (Braham), Mr. Edward Dalzell; solo flute, "Irish Fantasia" (Richardson), Mr. John Radcliff; song, "A Tar of the Queen's" (Watson), Mr. R. E. Miles; humorous song, Mr. J. Kift; finale, "The Watchman's Song" (Pearsall).

Endolithic Ivory.—In the making of switchboards, telegraph, telephone, and other electrical instruments, the lettering is a minor but important detail. The Endolithic Ivory Company, of 24, Well-street, Jewin-street, have sent us some specimens of their ivory lettering for these purposes to inspect and test, and the result is highly satisfactory. The specimens are beautifully white and polished, and the lettering very clean. On scraping the surface with a knife it took 50 scrapes to make the lettering even dull, showing that the lettering goes right into the ivory, and if each scratch means, say, several years ordinary wear, it can be seen that this process is far preferable to ordinary lettering where permanence is required. At the same time the price is far below that hitherto paid for engraving, even of an unsatisfactory kind. During the last year some hundreds of thousands of pieces for all purposes have been turned out, a large quantity being for address tablets, telephone and switchboard labels, etc. Single sets are supplied where necessary.

Elastic Foundations for Dynamos.—In many cases the vibrations produced by gas and steam engines in the buildings surrounding them are very objectionable, and M. G. Anthoni has been led to devise a method of overcoming this difficulty. The method is briefly as follows: A large trench is dug out, at the bottom of which is placed planking surmounted by a covering of sheet iron, on which is distributed a number of short vertical rubber cylinders, constituting at the same time an elastic and electric insulation. On the top of these cylinders there is placed a second plate of sheet iron, riveted to a framework, so as to give stiffness to the whole. On this is built a foundation in the usual way, provision being made for the foundation bolts, and sufficient space being left to properly allow of periodically cleaning the trough of any extraneous matter without disturbing the elastic supports. The steam and exhaust pipes are joined in the form of a large spiral at their upper ends so as to permit of their being elastic under the slight

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movement which takes place, and thus avoid the springing of joints.

The Electric Traction Company at Barking.—We understand the installation at Green Gate, Barking-road, for working the accumulator cars on that section of the North Metropolitan Tramway is nearly complete. The engines are now being set up by Messrs. Davey, Paxman and Co., and the six new cars built by the North Metropolitan Tramways Company at their Leytonstone works are also being electrically equipped with the Immisch motors and E.P.S. cells, under the active superintendence of Mr. Thomas Fraser, the engineer of the Electric Traction Company. This company will undertake the entire working of the line in the course of the next few weeks. This will be the first commercial test in England of the value of accumulator cars as opposed to horses, and is being looked forward to with the keenest interest by the whole tramway world. The experimental car, of which we gave an exhaustive notice in September last, has been running most successfully for the greater part of the past year, and the Electric Traction Company are very confident that this demonstration will prove a commercial success, by doing the work equally efficiently and at a less cost than horses.

Ferranti Machines for Paris.—A considerable stir has been caused among electrical circles in France by reason of the judgment of the commission which was appointed to consider the tenders for the central station at the Halles Centrale, in which the contract for dynamos was awarded to M. Patin, representative of Ferranti. The council had resolved that all material should be exclusively obtained of French houses, and although the tender was sent by a French house the dynamos are of English construction, and the commission are confronted with the question that if one, then all contractors ought to be allowed the right to employ foreign manufacturers. MM. Mascart and Potier, the only two electricians appointed on the commission, report as follows. M. Mascart says: "If I had to choose for my own installation or for a central station to be erected by me, I should give preference to the Ferranti machines. But as representing the town of Paris, and judging on its account, I consider the advantages of the Ferranti machine over that of Zipernowski not sufficient to necessitate the council going to foreign rather than to French industry." M. Potier, in his report, comparing the three projects—Siemens, Zipernowski, and Ferranti—says the two last have the greater efficiency, owing to absence of iron in the armature. He prefers the three Ferranti machines to six Siemens machines, as being easier to manage. The tender for Ferranti machines is the higher by about 40,000f., but there is 12 per cent. greater output. With these there will be an additional 7,200 watts for each dynamo of 140 h.p.; or for two machines 14,400 watts at equal expense of fuel, salaries, etc. The price settled upon for supply to customers is 15 centimes per 100 watt hours. Taking only 10 centimes, and 1,000 hours a year supply, each watt will produce an increase of one franc in the receipts. If Ferranti machines are employed, this means an additional income of 14,000f., against which is to be put the interest on the additional 40,000f. It is true the project of M. Patin comprises dynamos of 113,000 watts, while the engines will only supply 90,000 at the outside; but the contractor has given written guarantee for an efficiency of 88 per cent. even with engines of only 140 h.p., and additional engine-power can be added. Under these conditions, if the financial guarantee given by M. Patin are sufficient, M. Potier advises the sub-commission to accept his tender for high tension machines and accessories.

Electricity in Mechanics.—The need there now exists for engineers in general to study and work with electricity is rapidly forcing itself on the attention of those who have hitherto been exclusively mechanical engineers, and instances are becoming common of well-known engineering firms setting apart an electrical department and engaging an electrical expert. An interesting article, inciting those whose special department is mechanical engineering to further study of electric science, appears in the *Stationary Engineer*. "Electricity," it says, "is steadily and surely working itself into many places where steam and water have heretofore been thought all-sufficient for the purpose, and it is daily showing its superiority in many places. It is less expensive, requiring less attention, occupying less space, can be placed directly at the work, and through the various contrivances designed for its utility it becomes a greater task to show wherein it cannot be used to advantage than to point out the method of its advantageous application. The engineer who fails to make a study of electric machinery will soon find himself supplanted by the man that has taken the trouble to learn the principles and study the details of dynamos and motors sufficient to be able to care for them as well as he does engine and boilers. The demand for electrical engineers is as great to-day as the demand for mechanical engineers, and in most places one man is required to furnish the ability of both mechanical and electrical engineer. This state of things is, of course, very unsatisfactory to some of us who are inclined to think that we are now furnishing enough work and knowledge for the pay we receive. This is all very true; but we must not for a single instant forget that the world moves, and if we do not keep our eyes and ears open and keep 'up with the procession,' we are certain to get left when there are any of the good things around. Yes, the world certainly does move, and the requirements of men in any position are greater to-day than they were a few years ago, and we engineers wrong ourselves if we think that we are any exception to the rule. We must master all the improvements that are encroaching upon us. We must make ourselves familiar with the natural laws by which they are governed, study their minutest details, and become so thoroughly familiar with them that we can understand their slightest action. This we find it is necessary to do, or we will be supplanted by someone who will. To keep up with the advances of the times, we find it necessary to learn. When we become thoroughly familiar with a machine we find that it is quite easy to care for it; if defective, investigate it thoroughly, study its action and learn if you are familiar with the principles upon which it is built and have given the necessary attention to details. The electric machines that are now finding places in the engine-room, and are necessarily in charge of the engineer, need not be feared because electricity cannot be seen, and its presence only known by the results. Neither need we be appalled by the fact that we do not know for certain what electricity is; that matters not, so long as we know the laws of its action and can control it to our liking. Mysterious as electricity may yet be, learn the few laws by which it is controlled and you are its master; disregard those laws and it turns upon you to injure or destroy."

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THE INSTITUTION OF ELECTRICAL ENGINEERS.

The first ordinary general meeting of the old Society of Telegraph-Engineers and Electricians under its new title was held on the 10th inst., Mr. Edward Graves, president, being in the chair. It was announced that Prof. Silvanus Thompson had declined to receive the society's premium which had been awarded to him on the ground that he had been a member of council and that he considered such premiums were for other members than such as himself. The presentations of premiums were then made as follows:

The "Society's" Premium, value £10, awarded to Mr. Arthur C. Cockburn, F.C.S., member, for his paper on "Safety Fuses for Electric Light Circuits, and on the Behaviour of the various Metals usually Employed in their Construction."

The Paris Electrical Exhibition Premium, value £5, awarded to Mr. E. Stallibrass, member, for his paper on "Deep-Sea Sounding in Connection with Submarine Telegraphy."

The Fahie Premium, value £5, awarded to Mr. E. O. Walker, for his original communication "On Earth Currents in India."

The president-elect, Sir William Thomson, F.R.S., etc., took the chair and delivered his

INAUGURAL ADDRESS

On Ether, Electricity, and Ponderable Matter.

Gentlemen,—I beg to offer you my warmest thanks for the honour you have done me in electing me to be the first president of the Institution of Electrical Engineers. Fourteen years ago, when the then three-year old Society of Telegraph-Engineers honoured me by appointing me to be their president, the society numbered 570 members; it now numbers 1,550. It is gratifying to us to think how successful that young society, founded mainly, I think I may say, by Sir William Siemens, has been, and how much it has grown. But while we think with pleasure of the great increase of our members, that pleasure is saddened by the thought of how many of the old members are gone, and especially the first two presidents, Sir W. Siemens and Mr. Frank Scudamore. The genial presence of Sir W. Siemens is a happy recollection to many of us, I think I might almost say to nearly all present, and the thought that he will be no more with us is certainly a very great grief to all who have known him, a great loss to science, and a great loss to England. We look back upon Mr. Scudamore's presidency with great satisfaction, considering all that he did for the society, and his loss is deeply felt. Three of the presidents since I had the honour to serve are also gone, Mr. C. V. Walker, Colonel Bateman Champain, and within the past year Sir Charles Bright. The first Atlantic cable of 1857 gave me the happiness and privilege of my first acquaintance with Sir W. Siemens, and in the course of that work Sir Charles Bright was my colleague. He was engineer to the company, and I made his acquaintance during the 33 days when we were out of sight of land in the ever memorable "Agamemnon" expedition of 1858. Sir Charles Bright was there full of vigour and enthusiasm, and to his vigour, earnestness, and enthusiasm, in a great measure, was due the existence of the temporarily successful cable of 1858, and of the great consequences which followed from it, even though that cable itself had a very short life, having only three months of working time, and not more than three weeks of really practical useful work. Still, we must always look upon Sir C. Bright as a pioneer in the great work when other engineers would not look at it, and who thought it was absolutely impracticable; we must always look back upon our late colleague, lost within the last year, as having done great things indeed for the subject of the Society of Telegraph Engineers. The Society of Telegraph Engineers has grown, not only in membership, but in the extent of its province from the time of its foundation until now. It became the Society of Telegraph Engineers and Electricians a few years ago, and now the more appropriately representative title of the Institution of Electrical Engineers has been adopted. The original name included only telegraphy, but that was not then the only application of electricity to engineering—there then was electrometallurgy. Telegraphy and electrometallurgy were, I think, the only two branches of practical science to which electricity had then been applied, but since that time we have had a vast augmentation of the field. We now have telephony—electric transmission of power. The society may well recollect Sir W. Siemen's inauguration of the great subject of the electric transmission of power on a scale of practical usefulness. I think we may safely feel that to the Society of Telegraph Engineers in a large measure is due that practical development of electricity. We have now power electrically transmitted through factories to drive separate machines by separate motor-dynamos; we have now electric haulage, electric tramcars, and many other fields; we have the application of electricity to naval and military purposes, and, last but not least, we have the application of electricity to electric lighting. With all these grand subjects of applied practical science for our province, I think the Institution of Electrical Engineers may feel that it has a great and noble dominion. I find it difficult to remember the new title, but I am proud of it, as I am proud of being its president, and I would mention our allied society, the Institution of Civil Engineers, and remark that the province of the electrical engineer necessarily touches upon that of the civil engineer. When, 14 years ago, I gave my inaugural address, I endeavoured to impress upon the engineering world that architects made a great mistake in not being engineers, and in not qualifying themselves as engineers, and doing the work of engineers; that architects did not do their duty to their clients in not being engineers and understanding the engineering of the works, and making engineering science, particularly the dynamics of engineering, an essential part of the training of an architect. It is not necessary to make any animadversion on electrical engineers. I think in this respect electrical engineers know well that they must, before all, be engineers: they must be engineers, and they must learn engineering. Young persons who have a taste for electrical machines—and who that is young has not a taste for electrical machines, sparks, flashes, the artificial aurora borealis, and phosphorescent effects with the influence machine?—think they would like to be electrical engineers, and they think that electrical engineering is all ether and electricity. Now, I have continually to impress upon many anxious mothers, parents, that their sons must condescend to learn something of gross, ponderable matter, that electrical engineering is not all electricity and ether, but that the mechanics of ponderable matter is also part of the subject. The youthful aspirant to the honourable profession of electrical engineering ought to learn mathematics and dynamics. After having the elements of a good general education, he ought to learn mathematics and dynamics well; then a good deal of chemistry and regular mechanical and civil engineering, besides electricity. It may be said that juvenile life is too short. I do not think it is. I think if the other subjects are well learned, electricity may be learned in a few months. I am perfectly sure that, if a youth is qualified in other departments, the mere admission of electricity to the education of a competent engineer will not take so very long a time, and that the merely educational part of the work will not be protracted unduly by adding electricity to the branches learned in general engineering. I do not mean to say that if electrical engineering is the branch adopted there is not a prodigious and endless field proper in which the worker will learn every day of his life, though he lives more years than any person present. I wish just to make these few remarks in the beginning because they do seem to me of some practical importance, and worthy therefore of being put in the front of the remarks that I have to offer as the first president of the Institution of Electrical Engineers. And now these remarks have suggested to me a subject for the scientific exposition that I might give you in this evening's address—that is, Ether, Electricity, and Ponderable matter. The demand for something like a mechanical explanation of electrical phenomena is not new, but it is growing in intensity every year. The proceedings of recent meetings of the British Association, and especially of the last meeting of the British Association, illustrate the growing desire to know something below the surface, to know something of the inter-

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nal relations connected with these wonderful manifestations of force and energy which are put before us in the action of a magnet and in the working of an electrical machine. The addresses of past-presidents of the parent Societies of Telegraph Engineers and Telegraph Engineers and Electricians illustrate also the growing desire to know something of the molecular theory or dynamical theory of electricity and magnetism. Mr. Preece, in his address, pointed out how Maxwell had shown the velocity of light to be related to electricity in such a way that we can scarcely doubt but that the propagation of electromagnetic disturbances through space (which we have every reason to believe does exist, which, in fact, from known laws, we may say certainly does exist) we may believe it to be propagated with a velocity equal to that of light—that the propagation of electrical disturbance and of light may perhaps be identical. Mr. Preece alluded to the disturbance of the sun's surface, and simultaneous magnetic disturbances which had been observed in his telegraphs, and other operations of an electromagnetic character on the surface of the earth. Many presidential addresses, I rather think, though I may be wrong perhaps in my recollections, have opened the ground of the keen desire of an electromagnetic theory. Mr. Preece's address was in 1880; in 1883, if I remember right, Mr. Willoughby Smith alluded to some experiments which I considered to be very beautiful and instructive, which he was making, and of which he only gave a very slight reference in his address, illustrating the screening effects of sheets of different kinds of metal upon electromagnetic and electrostatic inductions. Electric inductions simply, we may say, because we began to fail to distinguish between electrostatic inductions and electromagnetic inductions. In his subsequent work Mr. Willoughby Smith gave an exceedingly beautiful and interesting illustration of the screening effects of lead, copper, and iron, of which a slight sketch was given in his presidential address. About the same time the subject was mathematically worked out with great power by several mathematicians, but perhaps most notably by Horace Lamb. I feel it almost invidious to mention names; there are so many workers who touched upon the same subject. Charles Nevin,* almost simultaneously with Lamb,† went through very much the same kind of work; in fact, obtained the same solutions of some important and interesting problems regarding electric currents in spherical conductors. There may be some difference with these two writers in point of priority, but I mention Lamb's name because the screening is more particularly developed in his great mathematical paper. In that ever memorable presidential address of Prof. Hughes another allied branch of electromagnetic induction was very admirably illustrated by experiments which are now more or less familiar to us all, but which are of themselves of an immensely suggestive and stimulating character both to mathematicians and to experimental workers. The very criticisms by mathematicians upon some of the experiments and modes of statement by Prof. Hughes have, with Prof. Hughes' own statements, given a stimulus and suggested mathematical and experimental scrutiny that might have been wanting for many a year.

One of the earliest problems in which electrical induction had to be considered was that of submarine telegraphy. The subject of induction in telegraph wires presented itself in a peculiarly perplexing way to the first workers in that department. There was the general knowledge of electromagnetic induction between two wires, which had been worked out by Henry and Faraday in a very full manner; that was the only kind of induction that was thought of by some of the pioneers of submarine telegraphy. Another kind of induction more thought of by others was the electrostatic induction due to the Leyden jar charge of the insulated wire. Faraday, in this department, as in the other department, was the origin of nearly all that we now know. Faraday explained in a very beautiful and clear way the electrostatic charge of the submarine cable, and showed how the electricity conducted through the cable from one end, to give what of potential is necessary in the middle or the other end of the cable—in the middle of the cable for any mode of working, at the other end of the cable for modes of working in which the other end is insulated—gave rise to the Leyden jar charge. Faraday pointed out (without going into any of these details, however) the doctrine of the conduction of electricity through the wire to supply the Leyden jar charge, which the wire must have, in the course of working, in order to be raised to the difference of potential from the earth required to cause the signal current to pass through it. Cromwell Varley made very important advances in that direction. At the meeting of the British Association, in 1854, in Liverpool he brought forward some very important developments of Faraday's doctrine. Then came on the great Atlantic cable question, and I always remember how that question came upon me. I see in Prof. Stokes 'presence with us this evening a reminder of the circumstances. I was hurriedly leaving the meeting of the British Association when the son of Sir William Hamilton, of Dublin, was introduced with an electrical question. I was obliged to run away to get a steamer by which I was bound to leave for Glasgow, and I introduced him to Prof. Stokes, who took up the subject with a power which is inevitable when a scientific question is submitted to him. He wrote me and some correspondence passed between us, and the result was that a little mathematical theory was worked out, which constituted, in fact, the basis of the theory of working submarine cables. In that theory electromagnetic induction was not taken into account at all. Leaving it out of account was justified by the speed of signalling which the circumstances of a cable extending 200 or 300 miles in length dictated. For a cable of more than 200 or 300 miles the speed of working was essentially limited by these electrostatic considerations, limited so much that the electromagnetic induction certainly could have no sensible effect; but the possible speed of working in a cable of 20 miles, 50 miles, or even 100 miles, was so great that in short lengths like those the electromagnetic induction might come into play. I worked out the subject partially myself. I found it necessary to do so to satisfy myself that the doctrine upon which the Atlantic cable project, then growing up, and upon which it was ultimately founded, was thoroughly trustworthy. I found it necessary to investigate the question of electromagnetic induction. This question was further forced upon one by communications that I had with my friends, Lewis Gordon and the two brothers C. W. Siemens and Werner Siemens, with reference to the Mediterranean cables. It was imagined that electromagnetic induction alone was the obstacle, and that the embarrassment in working through a submarine cable was due to electromagnetic induction alone. On going into the subject fully, it became demonstrated that electromagnetic induction would have no sensible effect in the proposed Mediterranean cables, and thus the proposal to put two thin wires close together in order to obviate electromagnetic induction was given up. Experiments in Germany had shown considerable electromagnetic induction on short lengths of cable, and that that embarrassment, or whatever it may be called, was diminished by using wires very close together. It was shown that the diminution of electromagnetic inductive influence would produce a corresponding increase in the electrostatic inductive influence, and when it was pointed out that the electromagnetic inductive influence would be absolutely insensible at the highest speed of working the proposed cables, the idea of making them of twin wires, close together, for metallic circuits was given up and the present type of cable was adopted. But now it is very interesting to us to find that old question revived. I myself laid it aside; it was in a corner of my mind, and in some corners of my notebooks, for some few years, and within the last forty days I have actually worked it out to the uttermost—really, for my own satisfaction. But in the meantime it has been worked out in a very admirable and complete manner by Mr. Oliver Heaviside, and he has pointed out and accentuated the result of his mathematical theory that electro-

* "On the Induction of Electric Currents in Infinite Plates and Spherical Shells," *Phil. Trans.* Roy. Soc., 1881, p. 307 (read Jan. 29, 1880).

† "On Electrical Motions in a Spherical Conductor," *Phil. Trans.* Roy. Soc., 1883, p. 519 (read April 5, 1883).

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magnetic induction is a positive benefit. It helps the current, it is the same kind of benefit that mass is to a body shoved along against a viscous resistance. Suppose, for example, we had a railway carriage being moved where there had been an inundation, through a quantity of mud or other matter which obstructed its progress. Or take a boat on wheels. We cannot take a boat in a fluid on account of the gravity, but suppose two boats of the same shape in a viscous fluid, one of them being ten times the mass of the other. If they are shoved off with a certain velocity, the boat of greater mass will take greater force to give it its impulse, but it will go further. That is Mr. Oliver Heaviside's doctrine of electromagnetic induction—it requires more electric force to produce a certain amount of current, but the current goes further. My example is a very crude way of putting it, and does not do justice to Mr. Heaviside; but the whole thing is worked out in a most complete, simple way, and the fact that the effect of electromagnetic and electrostatic induction taken together—they cannot be separated—is fully worked out. One thing that was known of old is made the subject of Mr. Heaviside's treatment of the cable proper--that is, the beneficial effect of leakage in clearness of signals. All telegraphists remember that, and two or three leaks in a cable, if they would remain constant and not introduce the extra trouble of earth currents, make the signals come out more distinctly; that used to be known, and the general reason was pretty well known and pointed out by mathematicians. Now Mr. Oliver Heaviside has taken that subject, and included it in his work. He has included induction of this kind along with electromagnetic induction; he has particularly accentuated it, and it is a practical point of importance that the question of clearness of signals is not simply, or even very important, how much is the current alternated at the remote end of the cable, how much is the amplitude of the electric current (or of the variation of the electric potential in another mode of working), attenuated in transmission through a thousand miles or two thousand miles of cable. A certain range is given at the sending end; what is the range at the receiving end? That is an important question, but it is not the most important question with reference to the clearness of signalling—in fact, we might almost say it is not an important question at all, because there are certain restrictions and limitations as to the speed with which submarine cables can be worked in respect of high potential. Setting that idea aside on the one hand, and considering the practical sensibility of the instruments on the other side, we have a large margin, even in submarine cables, for increasing the working power on the one hand, and increasing the sensibility of the instruments on the other. It is not the smallness of the signals at the receiving end that is the real difficulty in a submarine cable just now at all—it is the running of one signal into another, it is the want of correspondingly definite features between a single signal or a group of two or three signals at the receiving end. There are two things to be considered in respect to the distortion, as Mr. Heaviside has called it, of the signals in passing through a cable—one thing is the retardation of phase, another is the diminution of amplitude. If the retardation of phase was the same for periodic currents, alternating currents of all periods, then the retardation phase would be of no consequence whatever — it would not impede the distinctness at all. Again, if the diminution of amplitude was precisely in the same proportion for alternating currents of all periods, then, when we came to make up the signals, we should find that the signals would be transmitted with perfect sharpness. In fact, if we compare the transmission of electric signals through a wire with the transmission of sound through air, we have in the case of transmission of sound through air great alternation by distance, inversely as the square of the distance in fact, but the same for all notes. Again, retardation of phase depends upon the velocity of sound, the same for all notes; the result is that speaking, musical performances, and signals of all kinds in air lose none of their clearness by distance. It is just a question whether the very greatest distance at which a sound can be heard is due to any want of clearness, due to different alternations of the different notes, or the different elements forming the compound sound, or difference of retardation of phase. I must not keep you too long on this subject, but it is one of much practical importance. Mr. Oliver Heaviside considers that electromagnetic induction causes a less great difference in the attenuation of different periods than there is without it, and that electromagnetic induction, as we knew 40 years ago, tends to reduce the retardation phase to the same for all different notes, and, in short, the phase of electric signals is retarded exactly as much as the phase of luminous vapours is retarded if the signals have but sufficient frequency for the circumstances. It was known to the earliest workers in the subject, and Kirchoff pointed out that it was approximate to the velocity of light; and Maxwell arrived at a probable explanation of electrical effects by the influence of a medium, showing that the medium must be ether—the medium to whose motion light is due. Maxwell's electromagnetic theory of light marks a stage of enormous importance in the electromagnetic doctrine, and I cannot doubt that in electromagnetic practice we shall derive great benefit from the comparison of electrical effects, line by line following Heaviside's theory of dealing with submarine cables, and showing how greater clearness is obtained as that condition is approached. The comparison with light and sound is just one instance of how the highest mathematical power of working and judgment as to physical applications helps on the deep and profound theory, and drags it into a practical channel. The telephone, one of the added subjects of the society of which we are members, illustrates very splendidly these developments of the theory of the transmission of signals through a submarine cable. The telephonic signals have, in fact, sufficient frequency to make electromagnetic induction very sensibly influential, the frequencies corresponding from 250 periods per second up to two, three, or four times that which are the frequencies involved in speaking. The human voice, tenor and soprano, and the quality of the voice as affected by the overtones, also periods of frequencies of from 256 periods per second to 1,000, or 1,500 frequencies per second, are concerned in the fundamental notes and in the characterising overtones of the sounds transmitted by the telephone. There seems, no doubt, that the clearness of the telephone is, to a large degree, due to the circumstances that Mr. Heaviside has pointed out, that we have much less difference of attenuation for different notes, and that the frequencies of the notes in a telephone were independent of the practical dimension of the telephone wire. I can scarcely speak on this subject without just touching upon a question which I do not propose to enter fully upon to-night, that is the efficacy of iron and copper as telephonic conductors. The information given to me by Mr. Bennett, the engineer of the National Telephone Company in Scotland, leaves no doubt whatever but that there is very considerably less of clearness in speaking through an iron wire, such, for instance, as the first metallic circuit iron wire of the Post Office between Glasgow and Edinburgh, than there is in speaking through a copper wire of the same resistance. I shall say no more of this just now; it is an exceedingly difficult and complicated subject, but with Mr. Heaviside's investigation and with Lord Rayleigh's special investigations on the susceptibility of iron to very small differences of magnetic forces, differences of magnetic forces superimposed on even powerful magnetic forces or a large residual magnetism, the matter is in a very hopeful condition. The subject is in good hands, mathematical and practical, and I think before many months pass of the existence of the Institution of Electrical Engineers we may have an absolutely clear understanding of telephony through iron wires compared with telephony through copper wires. I intended to put a few figures on the board, but unfortunately they were left in a hansom cab, and I can only quote from memory. I made calculations for the problem of alternate currents through copper wire. I have not applied it to iron wire yet, but for either telephone wire or electric light wire with alternate currents I worked it out in Bessel's functions—every mathematician knows how to do it. It is an extension of Bessel's functions, a problem of periodic variations at one end of an infinitely long copper wire, or difference of potential between two parallel copper wires o a copper wire and a copper tube surrounding it

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for return—we may vary the thing about very much, according to circumstances. But after all, one of the very simplest things is this, two parallel copper wires. If the distance between them is a large multiple of the diameter of each, as is the case in practical telegraphy and telephony, the problem is as easy as the problem of a single copper wire in the centre of a cylindrical tube of copper. Well, now, as Mr. Heaviside remarked, and as everyone who has worked out the subject must have known, the distribution of currents within a copper conductor is quite independent of the surroundings, provided only they be symmetrical all round, or provided they be that of two parallel wires where the distance between the two wires is a large multiple of the diameter of each, and where the current in each is not sensibly influenced by that in the other by being arranged in concentric cylindrical areas of equal current density. Well, now, the distribution depends simply on the frequency, not at all on the surrounding circumstances. While speaking on such an abstruse subject as electricity, ether, and ponderable matter, I wish just to give one little piece of practical information to some, though it may not be to all. The table I have prepared will, I hope, appear complete in the report of this address, but in the meantime I will try and give one or two of the numbers which are rather interesting. Take 80 periods per second as the frequency, that is about what is conducted in the alternate-current system of distribution; at all events in one light system I know of—in the Grosvenor Gallery installation—that is the period of frequency, and I believe it is very much the same generally. Let us take this as an example. Eighty periods per second, take copper wire of one centimetre diameter, two centimetres diameter, and so on. Well, now, in copper wire of two centimetres diameter, the ohmic resistance is 8 per cent. more for the alternating current than for the steady current; in copper wire of 4 centimetres diameter the ohmic resistance is 63 per cent. more than for steady currents; in copper wire of 10 centimetres diameter the ohmic resistance is four times that it would be for steady currents. This is an interesting result—in copper wire of 100 centimetres diameter the ohmic resistance is 17 times as great as it would be for steady currents. It is also interesting that from 10 centimetres diameter upwards the ohmic conductance—that is, the reciprocal of the ohmic resistance—increases sensibly as the circumference simply, and not as the square of the diameter. The conductance for steady currents is as the square of the diameter all through; the conductance follows a law only expressible by these developments of Bessel's functions until we get to a certain diameter. When we get to so great a diameter that the shell, so to speak, the outer portion of the wire into which the current is practically defined, is moderate or small in proportion to the diameter of the wire, then above that you can all see without calculation that the conductance is in simple proportion to its circumference. You may say, practically, that from 10 centimetres upwards the ohmic resistance is in simple proportion to the circumference, with a deduction in the ratio of 79 to 70, the figure 79 corresponding to 10 centimetres diameter, 70 corresponding to an infinite diameter. This very imperfect explanation of the results may give some idea, but the complete table will show them for all sizes of copper wire from nothing to infinity. With a quadruple frequency the same figures apply to half diameter; there we get the telephone problem $80 \times 4 = 320$, that is among the frequencies for telephonic notes. Take the figures I have given, for instance, copper wire of 1 centimetre diameter for musical notes of 320 periods per second, the ohmic resistance is 8 per cent. greater than the resistance for steady currents; for a copper wire two centimetres diameter, frequency of musical note 320 per second, the ohmic resistance is 63 per cent. greater than the resistance for steady currents, and so on. Another important development from this theory is that there is much less importance in the conductivity of the metal for a telephonic wire than for ordinary electric work when we try to attain to it by thick conductors, such as I have been indicating. For example, take copper wire of 2 centimetres, the figures are a little complicated, but I will only say that, when circumstances are properly proportional, it is the square root of the resistance that we have to deal with instead of the simple resistance. Speaking roughly, the quadruple resistance is only twice as bad when the frequency is so great as to cause the effect of the ohmic resistance to be very much greater than the resistance for steady currents. The moral of this is not that you may choose wire of bad conductivity; on the contrary, take the best conductivity you can get, whether for telephones or for electric light conductors, but shape them so that the ohmic resistance shall not be too much augmented by the change of distribution of the current from uniformity which electromagnetic induction entails. The principles of working these are pretty well known to practical men, so that I do not think I need say much on the subject now. They have been known for a long time, but we are not much "forrader" in respect to the great question of electromagnetic theory. We have had a fine analogy from the time the known laws of electromagnetic induction were put into formulæ in the beautiful manner in which Maxwell put them, with the motion of a viscous fluid, the equations for which were given originally by Prof. Stokes. These considerations regarding the distribution of electric current in a conductor such as copper, and the distribution of motion of water in a viscous fluid disturbed by periodic variations at the surface, follow identically the same law. Mr. Heaviside, referring to this, has well said that this analogy is very useful because we can see the motions in a viscous fluid, and understand them and picture them to our minds, for it is more difficult to fancy we see the distribution of an electric current in a wire. Take this analogy. I am speaking of the distribution of electric current in a round copper wire, through which alternating currents of electricity are sent. Take a viscous fluid in a tube in place of the conducting wire, move the tube to and fro with a regular alternating motion, a simple harmonic motion. Imagine the tube I have here to be one of very great length filled with viscous fluid, such as treacle or thick oil, and having pistons at its ends to fulfil the laws that I am speaking of; the length must be very great in comparison with the diameter, and the place where we look at and think of the fluid is very many diameters from the ends disturbed by the pistons. In the first place, in such a tube, fitted with frictionless pistons, if the fluid were non-viscous, if it were perfectly liquid, the tube might be moved, but the fluid would not move at all. Water would move, but the more thick the fluid the more liable is it to take motion in that way. There is a perfect analogy between the motion of the fluid, the alternating motion of the fluid, transmitted inwards from the surface, and the distribution of electric current in a wire through which the effect of an alternate-current machine is being conveyed. Another very interesting analogy, which has exactly the same law as the other, is change of temperature in a conducting solid due to variations of external temperature. We have got our tube of fluid; imagine there a column of rock or stone, or metal, and instead of moving the tube to and fro longitudinally, let the atmosphere and surroundings of the stone column, or iron column, or metal column, be periodically varied in temperature. The law of penetration, of maximums, minimums, and zeros midway between the maximum and minimum of temperature in the one case is identical with the corresponding law for electric current in the first-mentioned case, and of fluid motion in the other cases. In each case we have a propagation inwards with diminishing amplitude; in each case the rate of diminution of amplitude corresponds to the retardation of phase according to exactly the same law. I need not take up your time in giving the law, but you can easily understand it. Well, now, we have a very perfect electromagnetic analogy for the simple case in the to and fro motion of a tube. Take another case. Here the thermal analogy fails us, it absolutely fails us; it is absolutely inapplicable to what I am going to speak of now. The fluid motion analogy still holds; take a tube of fluid and give it a motion round its axis; that action will give a tangential drag if the motion be very quick, and will follow the same law for the to and fro motion of the cylinder, and for the rotary motion of the cylinder. The question is this: Does the variation penetrate to a large distance in from the outside or not? If it penetrates in to only one-hundredth of the radius, then it is obvious that

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we shall have the same law of penetration inwards for the disturbance, whether for the case of rotatory motion of the cylinder round its axis, or of longitudinal to and fro motion; exactly the same thing holds with electromagnetic induction. The one case that I mentioned first is the most important for telegraph and telephonic current, but another of equal importance is that of a core within a solenoid through which an alternating current is being sent in opposite directions, producing magnetic lines of force parallel to the axis of the interior of the solenoid. Alternating magnetic forces induce electric currents in circles perpendicular to the direction of the forces; thus we have, as you all now know, currents induced in the solid metal core of a solenoid. A metallic core, such as iron, is a subject for investigation of an exceedingly easy character. The same Bessel's functions come in here just as they do in the other cases. But the inductive quality of iron, the different degrees of magnetisation according to circumstances, the increase and diminution of magnetisation or reversal of magnetisation, the great complications of inductive effects experienced with iron, introduce corresponding complications in the theory of the induced current, and other complications of a kind that present most formidable difficulties for mathematical analysis. The mathematical citadel of truth is there impregnable by any mathematical power that has yet been brought to attack that variation of magnetic susceptibility when the strength of the magnetic induction or magnetising force is taken into account. I am only going to say two or three words about an extension of that viscous fluid theory that allows us to take into account all that goes on both in air and in metal. I will confine myself to two very simple cases—parallel wires with alternate currents through them of the rotatory case; one cylinder rotated with a periodic motion of rotation alternately in opposite directions. The analogy I will state very shortly; it is simply this—to represent different metals in the analogy, densities of fluid proportional to the electric conductivity must be taken; the viscosity must be the same in all. The representative of an insulator in this analogy is a massless fluid almost devoid of inertia; perhaps I ought to say an inertialess fluid, because people attach their ideas to mass sometimes rather than to inertia, but in strictest dynamic language mass is taken as inertia. The inertialess viscous fluid must take the place of air; a viscous fluid of a certain density, but the same degree of viscosity must take the place of lead. Then, again, to take the place of copper, a fluid of six times the density of lead —the conductivity of copper being, say, six times the conductivity of lead—a fluid of six times the density is the analogue of copper in the viscous analogy. I shall not pursue the subject further, because to work it out with illustrations would run into more time than can well be afforded on such an occasion as this; but I would just call attention to the other case of rotation—exactly the same statements hold. I shall return to that presently, because I am going to speak of iron. When we come to iron, there is no difficulty whatever in considering the one or the other; but now one thing is hopeless—that is hardly the word: we are never without hope in science. I was going to use another word—despair. I feel the probability of my seeing the solution of it, I may say, is hopeless— the electrostatic effect. To get the analogy of electrostatic effect simply put in an inter-phase between the two surfaces, and give it such stiffness against change of shape as to require it to fulfil the conditions which our knowledge of the laws of electromagnetic influence teaches us exist. Put in at the inter-phase the requisite normal force, and the solution can be extended to include the submarine telegraph problem—that is, with electrostatic charge taken into account; the complete problem of a submarine cable where electromagnetic and electrostatic induction are both taken into account—but it is only by putting in quite an arbitrary manner a force at the surface to fulfil the requisite conditions that we can complete the analogy. The analogy I have just sketched cannot be considered as being in any respect a physical analogy. It is not molecular rotation of the fluid, the analogue to electric current is not velocity of the fluid—it is a quality derived from the simple motion of the fluid by the operation known as the Laplacean operation. The Laplacean of u, v, w is the electric current. Another way of putting it is the rotation of the rotation of u, v, w. The word "curl" was introduced by Clifford and Maxwell, and has, I grieve to see, been adopted by Mr. Oliver Heaviside. I object to the word—curve is good, but curl is bad, and the method seems to be not desirable or instructive, and, above all, not applicable to any practice of mathematics. It is too difficult a subject to explain now, but I will, just by an illustration, try to illustrate it by a case. Take in the viscous fluid analogue what corresponds to the steady current in a wire—here it is. Think of a tube, at one end of the tube press a piston in with a uniform motion in the neighbourhood of the piston. The motion is disturbed by the rigidity of the piston, and to a distance of 10 or 20 millimetres from the position the motion of the fluid takes a perfectly regular character. Suppose (diagram drawn) that represents the inner surface of the tube; a portion of the fluid is sticking to the surface —there is absolutely no slip at the containing surface. I make it to exactly represent a parabola, with its vertex in the axis of the tube. The surface is that of a paraboloid of revolution. The effect of the drag is a maximum at the side of the tube and zero at the vertex. We have two functions derivable from the consideration of the depreciation of the velocity. The first is the rate of shearing of the fluid, the second is the rate of change per unit change of distance from the axis of the rate of shearing. First, then, the rate of shearing, then the rate of change of the rate of shearing. The rate of shearing is equal to the tangent of the inclination, the angle i, the tangent of the angle of this curve to the transverse surface. The rate of change of the rate of shearing from point to point is the analogue of viscous fluid force through a tube. In it we have not the average velocity equal to velocity of electric current, but something quite intelligible and very clear, but it is not the velocity of the fluid. Now, perhaps, there is this in this idea—I think we have a mathematical definition of electric current which is not fluid velocity. Well, now, perhaps, some will say, Had not we better get an analogy in which fluid velocity is equal to the velocity of electricity? I do not say whether we had better or not, but this analogy gives us a motion of which the rotation is the magnetic force. Mr. Heaviside rather overlooks that merit in Maxwell's vector-potential; he objects to Maxwell's vector-potential. I do not like it, and heartily agree with him because I think it is an unhappily chosen name. Maxwell puts down in his formulas (as the foundation from which one step leads to magnetic forces, and the next to electric current) something which, when translated, gives us a mean of which the rotation is the magnetic force, and it seems to me that if we are ever to have a real theory here, it must be founded upon this view. The hand of the clock warns me that time is going on so rapidly that I must leave this analogy absolutely unfinished. Perhaps it is as well that we are obliged to leave it now, because the more we look at the result the less we like it if we wish to see a true mechanical explanation of electromagnetism. It is only a dream, an idea of a possibility that may ultimately lead to an explanation of magnetism. The work, the energy, is done in the wrong place. We find work done in the dielectric, this viscous, this massless fluid taking the place of the fluid. I must now leave it, but the reason that so much notice has been given to it to-night is that it is a perfect mathematical working analogy, and will be a useful and instructive kind of analogy, and a very potent aider in getting out and estimating out practical problems in respect to magneto-electric induction in dynamos, telephones, helices of electrical instruments, wire, and so on, in great variety of shape. But now there is another thought in connection with this subject, and that is the elastic solid thought. Will you allow me to read a very short statement which was published in the *Cambridge and Mathematical Journal* for the year 1847. It is dated Glasgow University, November 28, 1846, and it was written after I had been 28 days in my professorship, and is as follows: "Mr. Faraday, in his 'Experimental Researches in Electricity,' has set forth a theory of electrical induction which suggests the idea that there may be a problem in the theory of elastic solids corresponding to every problem connected with the depreciation of electricity, or with the forces of attraction and repulsion exer-

cised by electrified bodies. . . . . I should exceed my present limits were I to enter into an examination of the state of a solid body representing the various problems of electricity and galvanism, which must therefore be reserved for a future paper." I can say that now as I said 42 years ago. I have been considering the subject for 42 years night and day—I do not mean all of every night and all of every day—but there have been but very few days and nights on which I have not tried to find it out, but have not found it out yet. But we feel almost as if we are approaching towards it when we think of viscous fluid forced through a porous portion—a tubular portion filled with porous elastic matter. Let there be an elastic solid of exceedingly small density, and let there be a portion of it porous, but with the same aggregate rigidity, taking rigidity now instead of viscosity, somehow or other force a fluid through it; the pull of that fluid upon the porous solid will produce identically the same static rotations as we have of dynamic rotations, continued rotatory motion in the case of the viscous fluid—in fact, nothing but electricity and ether. The thing would be done. I would be perfectly satisfied if I were in the position of the juvenile electrician who thinks it is all electricity and ether, as if there was not another body—grave, ponderable matter. I should be perfectly satisfied if it could be so, but I cannot deal with that now. As to magnetism, I said I would return to that, and I want just to call your attention to this. Imagine (diagram drawn) to be the section of an ordinary helix or solenoid representing the copper core, through which an alternating current is passing. Whatever the current of electricity may be, I believe it does pull the other round. I do not think this is a dream of electromagnetic theory; I believe it to be reliable. Astronomers do not cry out and make their lives miserable because they cannot explain the motion of the earth through this elastic solid ether. It is an absolute mystery, and people who deal with optics and astronomy are not expected to be miserable because they have that difficulty and mystery ever before them. Are we to be absolutely unhappy, then, because while we say it moves, we cannot by any possibility say how it does move; no greater mystery with reference to the laws of matter has ever been suggested or imagined. Somehow or other, however, the ether is pulled round, it has got a twisting motion like that in the interior of a solenoid. Somehow or other it does give motion to the copper, and somehow or other there is a motion following these very laws that we have been speaking of, and illustrating the viscous fluid analogy somehow or other in the copper. Now, instead of an alternating current through the helix, take a constant current. A constant current; what can it do but turn round the ether to a constant angle? Just one other thing is possible: it might keep dragging the ether round and round; either one thing or the other it does. Either a constant current through this helix does drag the ether round and round inside it, or it drags it round to a certain angle proportional to the strength of the electric current; it does either the one or the other of these two things. Now, how on earth can iron differ from copper? Our interphasial law, depending on equal viscosities, is very simple; but when you introduce iron, you introduce an interphasial difference without anything that could possibly be a cause of viscous action whatever, or a cause of electrostatic action. A cause of electrostatic action requires distortion: you have no elasticity of an elastic solid without distortion. Well, now, all that you can do by applying a tangential force all round a cylinder is to turn it; if you keep turning the circumference you will keep turning the contents; and if you turn the circumference to a certain angle and leave it you will turn the contents to the same angle and leave it, and all the contents must be turned to the same angle. That is all we can get either from our viscous fluid analogy or the other analogies. The primary phenomena of the magnetisation in a bar of iron, the core of a helix, absolutely leaves it behind, and cuts the ground from under us in our viscous fluid analogy and in our elastic solid analogy. If it is to be a fluid going round and round, we must have an action depending upon the fact that all goes round together; if we have no action round and round, but merely a certain drag of the ether round to a certain angle, and then turning to equilibrium, we must have a force resisting steady rotation—we must, at first sight, have this debatable property of matter. Here is a solid body, I apply a force to it, a definite torque—that is, the effect of a couple of forces tending to twist (it is now called a torque, and not a couple)—a certain torque tending to twist a body round carries it round and round with accelerated motion. Well, now we must have an arrangement of matter in which a constant torque produces a constant angular displacement in a body, and does not produce rotation. The only thing that can do that is an inherent rotation existing in the molecules of matter. That seems the only thing that can do it, and that can do it certainly, unless you introduce this other idea that an elastic solid may be moored in space, but even that must be movable ether. The gyrostat shows the thing, and I will conclude with a perfectly well-known experiment with the gyrostat that will illustrate application of it with reference to the idea of a medium which has the properties of an imperceptible fluid, and no rigidity except what is given to it gyrostatically. Here is a representation of a molecular skeleton that can give us such a fluid, consisting of a set of squares joined by flexible threads. Here

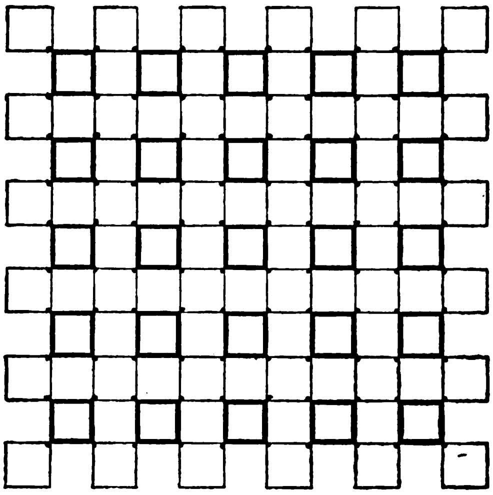


FIG. 1.

is a square pattern of rigid squares; the corners are connected by endless threads. There are 16 squares, and I have nine rigid endless wire squares connected with corners in this pattern. If these be pulled out with equal force in all directions, we have a kind of web. Well, now, in an ordinary cloth we can pull it in all directions in the direction of the warp and in the direction of the woof, and you cannot stretch it; but pull a thing like a pocket-handkerchief at 45deg. to warp and woof, then you can stretch it. You all understand that; surgeons do that generally, I think, for their bandages. Suppose the cloth is unstretchable except in the diagonal direction; the same with these squares: if you alter a square into a rectangle the area remains sensibly unchanged. The first change of the area is a diminution in whatever direction you do it, but that is proportional to the square of the strain, so that you may say, mathematically, that the area is unchanged. The constancy of the periphery, then, of each of these figures entails the condition of an approximate constancy of the area. Here, then, we have the skeleton work of a medium which, looked at in two directions, is incompressible and inextensible, but is exchangeable in area, and is freely extensible in any opposite directions provided you allow it to shrink in the perpendicular direction. Well, now, I say, put a gyrostat into each of those squares, and you have all that is wanted to fulfil almost any conceivable condition that I put before you. (A gyrostat was set going, and some details of its action explained.) Well, now, the upshot of it is simply this: imagine a gyrostat, such as this, in each one of the squares of this web; suppose the speed was infinitely great—a million million million times per second—it would take some thousands or millions of years to pass before the application of a torque would break down a wire by twisting it or turn it one degree. You can make it as immovable as you please by imagining the angle of the flywheel to be so great, and there is nothing to curb our

imagination in this respect. (A gyroscope was shown, and its action described in detail as illustrating the same ideas).

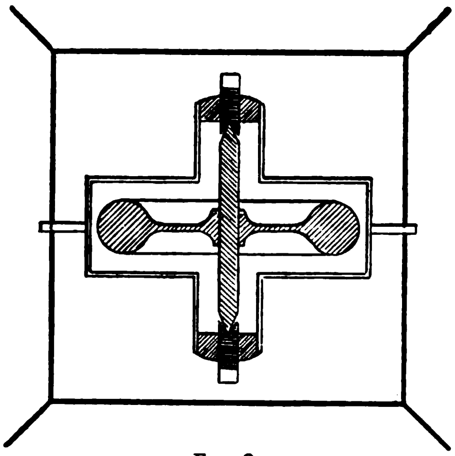


FIG. 2.

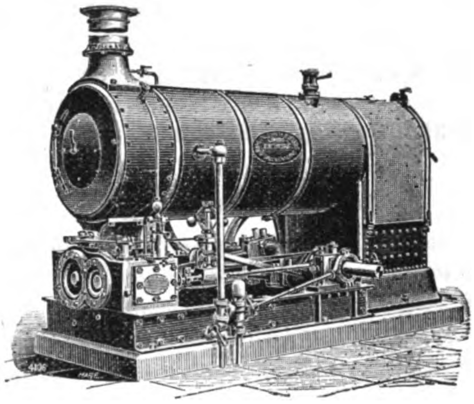
I shall not detain you more than two or three minutes longer, just to show that we have a specially elastic solid in the structure. Do not imagine that a structure of this kind, gross as it is, is necessarily uninstructive. Look at the structures of living things, look at the wonderful tactics in the structure of organic beings, think of what we have to explain in electricity and magnetism, and allow at least that there must be some kind of matter. We cannot suppose of dead matter to be without form and void, and without any structure. There must be molecules of some shape, they must have some relation to one another, and surely we can imagine the things exist though we may be unable to perceive it. I do not admit that this is playing at theory, but it is helping our minds to think of possibilities, so that here is a structure that can be produced which is a perfect liquid, that is an incompressible, frictionless liquid, without any gyrostatic arrangement when no gyrostatic arrangement is given to it. Now, consider for a moment the effect of introducing gyrostats into each of these squares. Each of the squares becomes immovable, and you get a set of elastic threads stretched to the corners of immovable cubes—immovable in rotation, but perfectly free to take translatory motion. There you have a body, then, which you need not distinguish from an ordinary elastic solid, so far as translation effect, so far as motion as a whole is concerned, but which, if you try to turn it, will not absolutely resist, but will only admit of turning by stretching of the connecting elastic bands; it will not be immovable in respect to turning, but it will be balanced by a constant couple, with a constant degree of rotatory displacement. Thus, upon this solid, the effect of a constant couple is not to produce continued rotation, but to produce a balance. Constant displacement of that balance might last for millions of years if the rotational moment of momentum is but great enough. Lastly, I should just say briefly this, that the rotational quality of ether in iron must be enormously less than in copper or in air. The total rigidity due to elastic action and gyrostatic effect in all non-magnetic bodies is the same. The total rigidity of ether is the same in all non-magnetic bodies. In iron it is less through less gyrostatic contribution with equal elastic contribution to the rigidity. Those conditions fulfil exactly what we want for the relation of ether between air and iron inside the helix of an electromagnet. But now we are only landed in an absolutely immeasurable difficulty. We have a strange solid forced between the bodies connected with the system. Why is it that they do not balance themselves in the solid. How can there be a solid giving rise to these prodigious effects, and as when copper will fall down at the rate of a quarter ampere per second until it gets away free, and so on? How can it be that this prodigious effect is passed through a solid, and yet other forces be perfectly free to move within that solid? I can only say that we have done all we can to think out this subject, but it merely gives us a dynamical theory of one part of it. The electrostatic part, our first love, has been left out in the cold, though I have spoken of it two or three times; but we do not touch it or get near it in any of this doctrine, and we do not get the mutual attraction between iron and iron, nor near the motion of the body that demonstrates this force—we only get the conclusions which mathematical theory lead us to believe exist. I must give up saying that the difficulties are so great by way of forming a comprehensive theory that we cannot imagine a single thing that leads us towards a conclusion. We cannot imagine it, but this time next year or this time 10 or 100 years it will probably be as easy to think we can understand that glass of water as to understand the solids that are now incomprehensible; the mysteries will be no mysteries at all, but the scales will fall from our eyes, and we shall be able to look at things in a different way than now. I must ask you to pardon me for bringing it to such a conclusion, that we really know nothing about this grand subject which constitutes the province of the Institution of Electrical Engineers.

Votes of thanks were accorded to Mr. E. Graves, the retiring president, and Sir W. Thomson for his address.

1888.

We continue our *résumé* of the work of 1888, but owing to the space devoted to Sir W. Thomson's address, are compelled to leave the conclusion to another issue.

MESSRS. RANSOMES, SIMS, AND JEFFERIES, LIMITED, of the Orwell Works, Ipswich, who were among the first to adapt their engines to the requirements of the electric light, are supplying a most extensive assortment of engines of various types specially adapted for driving electric machinery.



Their compound stationary engines, of the "Undertype," of which we annex an illustration, have given the most excellent results, both as to economy in fuel and stability in work. The automatic governor expansion gear with which these and all Messrs. Ransomes' engines may be fitted has been lately still further perfected. The cut-off is varied by the action of the governor between 0 and 75 per cent. of the stroke, according to the actual load on the engine; and the exact amount of steam necessary to do the work required being admitted at full boiler pressure up to the point of the cut-off, the entire benefit of the principle of expansion is obtained. In addition to the advantage arising from the economy effected in the fuel consumption by the adoption of this gear, the speed of the engine is maintained practically constant under the greatest possible differences of load, the variation in the number of revolutions in no case exceeding about 2 per cent. from the mean.

For temporary purposes Messrs. Ransomes' portable engines can be highly recommended. In addition to the front platform, which is already well known to our readers, they have lately arranged a platform extending from the firebox end, which enables any stock engine to be used, thus ensuring prompt deliveries. One of these engines carrying a dynamo was used with great success during the dark winter afternoons at the Ipswich Cattle Market by a local auctioneer, enabling him to conclude the sale of his stock in one day, greatly to the convenience of himself and his patrons, and with a consequent saving of time and cost. Besides having supplied engines for driving electric light plant in this country, Messrs. Ransomes, Sims, and Jefferies have during the year delivered engines for similar work to France, Italy, Russia, India and Australia.

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Vols. I. and II., new series, of "The Electrical Engineer" *are now ready, and can be had bound in blue cloth, gilt lettered, price 8s. 6d. Subscribers can have their own copies bound for 2s. 6d., or covers for binding can be obtained, price 2s.*

NOTICE.

During the course of the past year we issued steel engraved portraits of Mr. E. Graves, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. Wollaston, M.D., F.R.S., *and* Sir Humphry Davy, F.R.S. *The portraits of* Prof. D. E. Hughes, F.R.S., *and of* Dr. J. Hopkinson, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

THE PRESIDENTIAL ADDRESS.

The selection of Sir Wm. Thomson as the first president of the Institution of Electrical Engineers was a happy one, inasmuch as he is the greatest living exponent of electrical, we might say physical science. The new title of the society is comprehensive enough to include every class of electricians, whether they be devoted to the pure or the applied branches. History contains very few names equally, nay superlatively, eminent in both branches, and that of Sir William Thomson stands almost, if not quite, at the head of the short list. We have during our connection with electrical literature been brought into contact perhaps more extensively than most people with men who have been students at Glasgow under Sir W. Thomson, and men who in America have worked with Edison. We never yet remember to have met one of Thomson's men who had not the profoundest admiration for the master, nor one of Edison's who was not prepared to swear an affidavit that he is the only inventor under the sun. In both cases there is one and none other. Sir William's dicta may be, and often are, quite incomprehensible to the ordinary mind, but they are received, like the laws of the Medes and Persians, as perfect—hence requiring no change. It is to him that the younger physicists look, and if their theories or their work meets with his approbation, they feel confident that the ultimate conclusion about the work will be that it is good. There is a spirit of emulation amongst his students that has led and is leading to important investigations in many branches of physical science. The professors of the younger universities are largely recruited from Glasgow. The mere fact, then, that the Institution has such a president should induce the members to contribute during his period of office, as far as they can, papers and information which shall inaugurate a new era of usefulness of the society.

Coming now to the immediate subject of this article, there are three points in the presidential address to which reference must be made, but only upon one of these shall we dwell at any length. There is the wonderful and highly imaginative theory put forth for those given to discussing and thinking about the transcendental, to reflect upon, but this portion of the address is not for the multitude. We take it for granted that the theory is put forward only as a tentative one, and, considering this, we reflect that the ancient Greeks, possibly the Egyptians and Chaldeans also, possessed wonderful theories about our solar system and the motions of the bodies contained therein. Since those olden times, however, the suggestions of Newton and others have somewhat simplified the older theories, and we may imagine ourselves in relation to electrical theories to be somewhat in the position of the Greeks with regard to astronomical problems. The

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theories advanced have a value, but as knowledge advances these theories will give place to new ones, and undoubtedly the hope of every student is that the theory which is to come will be simpler than the one that has preceded it.

"There is more in heaven and earth, Horatio,
Than is dream't of in your philosophy."

No doubt Shakspere was right, as was the Psalmist in his physiological surmise, that we are fearfully and wonderfully made. It is, however, these fearful and wonderful theories that accord best with certain phenomena, and have been deduced therefrom by the best trained investigators this earth has ever known.

The second point to which we would direct attention is the eulogy upon the work of Mr. Oliver Heaviside. This may not be the best place to record certain facts in connection with Mr. Heaviside's writings, but we venture to do so for many reasons, not the least of which is the pleasure we feel in having our views corroborated by so eminent an authority as Sir W. Thomson. Putting aside the papers that appeared in the *Phil. Mag.*, the articles that were given in the *Electrician* were given in spite of the most strenuous opposition by the proprietors and every member of the staff, except the late editor. Hence possibly the singularity of the sudden cessation of the articles which has so frequently been remarked upon that the reason may not be uninteresting. Previous to Sir W. Thomson's acknowledgment of the magnitude and value of Mr. Oliver Heaviside's work, Mr. Preece had called attention to certain parts of it as worthy of the closest attention, and forestalling later workers in the same direction.

The third and most important point to ordinary mortals is the advice given to parents and such as would enter the profession of electrical engineers. Reference was made to this advice by one of the subsequent speakers, but Sir William's advice was perfectly sound and just. The amount of electrical knowledge required by the ordinary electrical engineer can be obtained in a few months. That knowledge, and that time, has nothing whatever to do with the student desirous of entering into the domain of pure science and theoretic investigation or investigation into theories. Electrical engineers do not care a dump (use any other expression if this is not suitable) about theories: they want something that will assist them to gain bread and cheese. Professors are not too well paid in this country to make men very envious of their profession, and if they were better paid the number of openings for young aspirants is not so great as to tempt many to depend upon getting into one for a livelihood. We should like to see professors, like the woman's best bonnet in its band-box: they should be highly honoured, well paid, worked moderately, and kept from the Patent Office and consulting work. At the present time we give them butlers' wages, and shut our eyes to their efforts to divide their labours. Young men may accept Sir William Thomson's dictum in this respect: Get a good general education as a foundation, never mind about Latin or Greek, prefer German and French. Upon the general superpose the special. Study the higher branches of mathematics, pure and applied. A good knowledge of mechanical and civil engineering, especially mechanical, should be a *sine qua non*, and then comes the special electrical knowledge that can be applied in practice.

CORRESPONDENCE.

BATH ELECTRIC LIGHTING.

To the Editor of the Electrical Engineer.

Sir,—The tenor of Mr. Massingham's letter affecting my company in your last issue and the sympathetic comments thereon in the electrical journals being calculated to create the impression among local authorities throughout the country that they are likely to be denied the benefit of competition in determining to whom they should allot the areas within their jurisdiction, I shall be obliged by your kindly giving the widest publicity to the announcement that the House-to-House Electric Light Supply Company, Limited, whose engineers have hitherto constructed the only central electric lighting stations for the distribution of electricity throughout an extended area by means of underground mains, is prepared to place its experience in both electric light supply and central station construction at the disposal of local authorities everywhere in the United Kingdom.

The House-to-House Company, as its name implies, has no local predeliction whatever beyond the usual commercial inducements, and it will be prepared either to apply to the local authorities for permission to apply to the Board of Trade to undertake the business of supply within their areas on its own account, or in conjunction with local capital, or to erect for local authorities or independent supply companies central stations on the model of its own at Kensington, which is, by general admission, the most perfect of its kind.

To this end my company endeavours as far as possible to watch the progress of central station development in all towns in the United Kingdom which in virtue of their population present a promising field for the electric light; and its letter to the Bath City Council was prompted by the report of the proceedings of that body, from which it appeared that a contract had been somewhat reluctantly concluded with Mr. Massingham for street lighting only by means of overhead conductors on the faith of representations to the effect that the present position of electrical science did not permit of the work being accomplished by means of underground mains.

Believing, as my directors do, in the advantage to the public of being supplied under the Electric Lighting Act, which not only requires an underground service, but secures rights to the consumer, with corresponding obligations on the part of the supplier, they felt that in these circumstances they would be best protecting the interests of the ratepayers of Bath by applying to the Corporation for permission to apply to the Board of Trade to light a limited area of the city for a limited period under a license tenure; and although the unfavourable editorial comments of the electrical journals on their proceeding have been brought to the notice of my directors, they regret to say they can see no reason to induce them to abandon the step they have taken.

We cannot attempt to justify our ignorance of Mr. Massingham's claims to the consideration of his fellow

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citizens. All that we knew about him at the date of our letter to the Corporation of Bath was that he was a most respectable boot and shoe maker in that city, and all that we have since learnt on his own admission is that, so far as electricity is concerned, he is "only an enthusiastic admirer of the light of the future."

My directors venture to believe, however, that such qualifications are inadequate for the proper discharge of the responsibility of undertaking "to introduce electricity into several towns of the West of England"; but, be this as it may, they trust that if they should follow Mr. Mas singham in extending their operations in the future to such places, the electrical press will not in that event bestow its support on him and withhold it from them.—Yours, &c.,

H. St. John Winkworth,
Secretary House-to-House Electric Light Supply Company, Limited.
117, Bishopsgate-street, London, E.C.

ELECTRIC LIGHTING.

The following letter from Mr. Hammond has appeared in the *Times*, and was followed by one by General Webber in continuation of this subject, both being dated Jan. 10:

"Sir,—Your admirable leading article in to-day's issue so completely sums up the situation with regard to the electric lighting of the metropolis, that there is hardly anything left for me to reply to in the communications of Mr. Erskine and Lord Crawford.

"I should like, however, to have the opportunity of pointing out in reply to the first gentleman that my letter was by no means intended to be an attack upon the electric lighting industry, in which I am personally so closely concerned; nor is Lord Crawford correct in assuming that my wish is, while advising that no monopolies should be given to others, to seek one for myself. I am, however, quite in accord with both these gentlemen in the views they express that no extensive electric lighting can take place in the metropolis or elsewhere except under the sanction of provisional orders, and I am confident that this will be the form of tenure which will eventually attract capitalists to the industry, though it is curious to note, as an argument upon the other side, that Lord Crawford's own shareholders have subscribed upwards of half a million sterling without the security of either a provisional order or a license, and that they have expended the greater part, if not all, of this sum in the execution of works which at the moment depend for their continuance solely upon the sufferance of the owners of private property which their overhead mains traverse; and that another company has also succeeded during the past six months in obtaining a like sum without any Parliamentary powers whatever.

"Your correspondents are both wrong in supposing that I advocate for permanent work a tenure by license in preference to a tenure by provisional order.

"My main contention was stated in my first paragraph, which I venture to repeat, as follows:

"'1. No district lighting has up to the present time been carried out in the metropolis of so satisfactory a nature as to warrant the Board of Trade and the local authorities in proceeding at once to the apportionment of the metropolitan area by means of provisional orders, and no district lighting whatever has been carried out *over an extended area* by means of *underground mains*—the mode of distribution contemplated by the Act.'

"No refutation is made by Lord Crawford's statement that an extensive system of overhead supply is already in the field, nor by Mr. Erskine's statement that his company has admirably performed (which I am perfectly ready to grant) some excellent lighting over a very limited area.

"That district electric lighting can be carried out over an extended area by means of underground mains has been set at rest by the work of the Eastbourne Electric Lighting Company, where such a supply system has been in operation for the last six years, and where the mains are some 20 miles in length.

"My sole object in writing to you was to make known through your columns that the Board of Trade distinctly denied the truth of the assertion which Lord Crawford made on the 21st of December last, and I am surprised that, in spite of the official denial quoted in the Board of Trade's letter of the 29th of December, Lord Crawford, on the strength of a newspaper paragraph which he refers to as 'apparently communicated officially,' should still persist in repeating his misstatement.

"It is most important that at this juncture the local authorities in the metropolis who are seeking to discharge their responsibilities under the Act should be made aware of the real state of the case, so that they might not refuse consideration, as some of them have hitherto been inclined to do, for licenses for limited areas, on the ground that they would not in any case be entertained by the Board of Trade.

"I feel, indeed, that in the interest of the industry and of the public generally, it is desirable that the utmost publicity should be given to the fact that, at present, at any rate, all the Board of Trade has decided is that such applications for licenses as those which relate to extensive areas in the metropolis are inadmissible, but that the Board of Trade is prepared to consider on their merits the applications of electric light supply companies for licenses for limited areas.

"It is quite true that I assume that the powers granted under provisional order over a certain area will practically preclude the granting of any competing power over the same area, although I am, of course, well aware that for the purpose of weeding out incompetent companies the Legislature has expressly provided that powers may be granted to more than one company concurrently over the same district.

"While recognising that the powers to be conferred under the Act do not constitute a monopoly in terms, I venture to believe that they will prove to be a monopoly in fact, and the experience of the gas companies, which resulted, after years of waste and confusion, in the system of 'districting,' is to my mind conclusive on the point. All that my argument assumes is that the practical inconvenience and expense of duplicating mains in the same street, and the difficulty of inducing another company to enter upon the unoccupied portion of an area the best of which has already been appropriated, will afford an incompetent company a practically unlimited opportunity for bungling. Indeed, I venture to say that it hardly follows, as you allege, that, because an area is occupied by wires and plant in working order, the company is doing its work efficiently. Consumers in one area might be served by a company whose light was normally inefficient and continually failing, while consumers in another might be served by a company dispensing a bright and continuous light.

"With regard to the possible action of the county council in the matter, I quite concur in the view that the industry is safe in the hands of the Board of Trade, but I have read nothing in the letters of your correspondents causing me to alter my opinion that the interests of the public generally, and of the electric lighting industry as far as the lighting of the metropolis is concerned, will be best conserved by the granting of a limited number of licenses for short terms and for limited areas before dealing with the allotment of the whole of the metropolitan areas by provisional orders with a 42 years' tenure.

"The difficulty of obtaining capital does not arise, because there are amply sufficient funds in the hands of the supply companies already in existence to efficiently carry out the work."

"Sir,—Your leading article of this date on the electric lighting industry will be read with feelings of gratitude by all who have studied the subject.

"The Paris Municipality, in granting concessions to six *permissionnaires*, has approached it in the same spirit—namely, quoting your words, 'We do not want oppressive monopolies, but we cannot afford to throttle enterprise by stipulations which discourage investors.'

"They go further, and, having studied its difficulties, will not allow the *permissionnaires* to spend in competing with one another the money that is subscribed by the public for remunerative works. At the same time they

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provide for a revision of the rates of charge for electricity to the consumers every five years, subject to a scale that slides with the profits.

"I trust you will permit my adding to the information you have already received that, although none of the provisional orders taken out in 1883 are now in force, there is one in operation, which was obtained by the Chelsea Electricity Supply Company, and confirmed by Act of Parliament in September, 1886.

"When the 'tenure' was extended last year from 21 to 42 years, that company, which had previously failed to raise the necessary capital, found no difficulty in doing so. They immediately made contracts for buildings, machinery, and a system of undergound distributing mains, and those contracts are in full course of execution.

"They have also been for some time breaking up some of the streets of Chelsea, and laying down mains in a 'thoroughgoing fashion.'

"The system they have adopted affords sufficient access to the cables for the repair of the insulation and the removal of the cause of leakage, without having again to disturb the streets, and without any necessity for accommodating the wires in tunnels accessible to workmen."

ELECTRIC LIGHTING OF THEATRES.—III.

Savoy Theatre.

The installation at this theatre was designed and carried out by Messrs. Siemens Bros. in 1881, and is still in charge of one of their engineers, Mr. Nebel, who has worked out a very perfect system of theatre lighting by electricity. Pending the laying down of a permanent plant, with which to light the Savoy Mansions Hotel as well as the theatre, the original plant has been removed from the iron shed, which formerly stood where the hotel now is, to the basements of the buildings between the Savoy Theatre and the Embankment. The whole of the theatre—both before and behind the proscenium wall—is lighted electrically; but gas is still used to some small extent in the passages, and also in the auditorium in order to warm it.

The plant consists of one Robey and two Marshall portable engines of 20 h.p. nominal each, and of three Siemens' dynamos. The Robey engine is driven at 125, and the Marshall engines at 95 revolutions per minute, with a steam pressure of 75lb. The dynamos are of the B 11 type, and are compounded to have a constant E.M.F. of about 90 volts at the 850 revolutions per minute at which the engines drive them by means of belts and counter-shafting; they can give current up to 500 amperes each. One of the dynamos, driven by the Robey engine, does the whole of the lighting not connected with the performance. A second, driven by one of the Marshall engines, lights the battens, and the third, driven by the remaining Marshall engine, lights the auditorium, sidelights and float. The regulation of the engine is entirely by hand; the driver is told to keep the pointer of the speed indicator at a certain mark, and has, further, a pilot lamp to guide him. There is no possibility of the house being plunged into total darkness by any breakdown of the machinery, as the engines and dynamos divide the load, and are quite independent of each other. The lamps used throughout the theatre are of the Edison-Swan pattern, take about 0·65 amperes at 88 volts pressure and give out 16 c.p. A large proportion of the lamps have lasted considerably over the estimated 1,000 hours. All the fittings of the auditorium and the front of the house are the same as those put in originally, and are by Messrs. Faraday and Son; they are very artistic and add much to the beauty of the decorations. The auditorium is lighted by three tiers of brackets—each bracket supporting three glow lamps in frosted glass shades — which run round the inside of the auditorium. The lowest or balcony tier contains 12 brackets; the second or circle contains 22; and the highest or gallery, 16; so that, in all, 150 lamps are used to light the auditorium. The front of the house includes the refreshment bars, corridors, offices, etc.; a large number of single lamps are used in this part of the house, but there are also some elegant electroliers in the bars and cloakrooms. In all, 165 lamps are used to light this part of the house.

The stage is provided with six battens, 20 lengths of sidelights and the float. Each batten has two rows of lamps, the one row containing 90 coloured, and the other the same number of white lamps. Each batten is provided with a separate switch, so that any of them can be lighted independently of the remainder, and there is also a two-way switch for changing them all simultaneously from coloured to white light, or *vice versâ*. The sidelights, which can be equally well used as ground lights, consist of 20 lengths. Each length contains two rows of eight lights—the one coloured and the other plain. Each length has a flexible cable, containing the going leads to the coloured and white lights, and a middle common return lead attached to it. The cable ends in three copper plugs fastened to a small block of wood, and each plug is insulated from the others and connected to one of the leads. Round the stage, sockets are let in corresponding to these blocks with plugs, and connected to the sidelights switchboard. If, then, a length is wanted at any particular place, all that has to be done is to press in flush with the stage a block into the nearest socket and place the length attached in the required position. Both the battens and the sidelights had formerly in circuit variable resistances and switches for regulating the light from them so that eight degrees were obtainable from each, but at present these resistances are not in use. The float contains 70 white lights, and, by resistances and an eight-way switch, as many degrees of light are obtained. Each music-desk in the orchestra is fitted with a lamp having such a resistance permanently in its circuit that, when they are turned on in dark scenes, they give a faint red glow sufficient to enable the musicians to read their music, but made, by shades, quite invisible to the audience. The dressing-rooms and passages behind and beneath the stage are lighted by 145 more lamps: in each dressing-room the mirror has attached a glow lamp on either side of it, and this is found a great convenience for making up, etc., as the artists can have their faces close to the mirror and to the light without danger or discomfort.

The whole of the stage fittings are on an incombustible system designed by Mr. Nebel. The battens and sidelights consist of strips of sheet iron about $\frac{1}{16}$in. thick and 12in. wide, and of the required length. To these backs are fastened, at intervals of 24in., porcelain insulators carrying two copper strips, each $\frac{1}{16}$in. thick and $\frac{3}{8}$in. wide running the length of the sidelights or batten, at about $\frac{3}{4}$in. from the sheet iron and two inches apart. Between these copper leads any required number of lamps at any required distance apart can be rapidly inserted by means of specially designed porcelain holders. These holders are so designed that lamps can neither be shaken out of place nor short-circuited.

The advantages of the electric lighting of the stage considered specially important in the Savoy Theatre are the absolute safety from fire; the easy manipulation and greater range of regulation of the light, and, as a consequence, a considerable reduction of the staff of gas men; the greater range of disposition of lamps, as they may be put as close to the scenery as is required; the prompt working of changes; the possibility of completely extinguishing the light on the stage; and, lastly, the important advantage to the singers of the absence of the overpowering streams of heated air and products of combustion from the argand burners in the float. The management experience all the advantages of lighting the auditorium and front of the house we have enumerated in previous numbers, and we may mention, as an important point, that the theatre has only *once* been redecorated since the opening in 1881, and that a *substantial* diminution in the rate of insurance is obtained by the management from the fire offices.

Mr. Nebel considers that the dusting or washing of the glow lamps every four weeks is the only disadvantage they meet with, but we may remark that other managements have considered that the reduction in trouble in cleaning the globes surrounding the lamps used is immensely in favour of electricity over gas.

Two arc lights in the carriage entrance are also run off the same plant used for the incandescent lighting.

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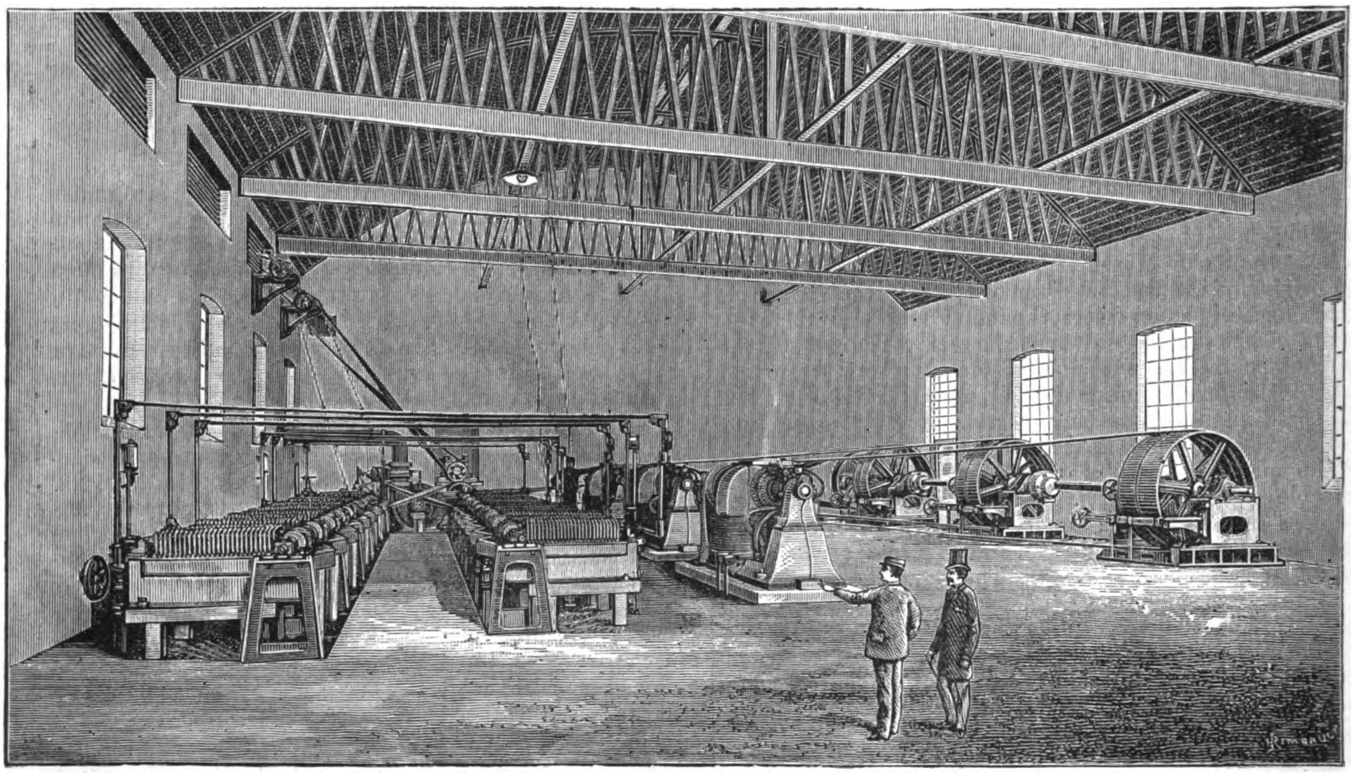
THE HERMITE ELECTRO-CHEMICAL BLEACHING PROCESS.

A description of this process will be found in our issue of May 11, 1888. We are now able by the accompanying illustration to represent the arrangement of machinery for this process lately installed at Messrs. Evans and Owen's Paper Works, near Cardiff. The plant is capable of producing equal bleaching effect to two tons of bleaching powder per 24 hours, and was constructed and installed by Messrs. Paterson and Cooper to the order of the Hermite Company. Briefly described, the Hermite process consists in manufacturing a solution of high bleaching power by electrolysing an aqueous solution of magnesium chloride. The salt is decomposed by the current at the same time as the water. The nascent chlorine, liberated from the magnesium chloride, and the nascent oxygen, liberated from the water, unite at the positive pole, and produce an unstable oxygen compound of chlorine of very high bleaching power. The hydrogen and the magnesium go to the negative pole; this last decomposes the water, and forms magnesium oxide, whilst the hydrogen is disengaged. If in this liquid coloured vegetable fibre is introduced, the oxygen compound acts on the colouring matter, oxydising it. Chlorine combines with the hydrogen to form hydrochloric acid, which finding itself in the presence of magnesium in the liquid, combines with it and forms the initial chloride of magnesium. Thus a complete cycle of changes goes on so long as the electric current acts on the solution in the presence of colouring matter. The cycle is a perfect one, in which there are four elements: the electric current, chloride of magnesium, water, and the colouring matter. Only two of these elements are used up whilst bleaching: the electric current and the water. The magnesium chloride serves over and over again. There is only a simple displacement of molecules, and the chloride acts as a vehicle to discharge the nascent oxygen on the colouring matter. Mr. Eugene Hermite, the inventor of he process, has found, after prolonged research, that it is magnesium chloride which of all chlorides gives the only commercial and complete results.



The plant at Messrs. Evans and Owen's works consists of 20 electrolysers arranged in two rows, through which the solution of magnesium chloride is constantly circulated. Each electrolyser consists of a galvanised iron box open at the top and with a perforated pipe at the bottom. The box is filled with the electrodes, which consist of a series of platinum plates connected to the positive pole of the dynamo, and a series of circular zinc plates interspaced with the platinums and connected to the negative pole of the dynamo. The solution is admitted at the bottom through the perforated pipe, and overflows the sides of the box, passing in between the plates, and, being decomposed, then falls into a cement tank underneath. From this bottom tank it is taken by means of a 12in. centrifugal pump into the tank above, and is ready to pass through the electrolyser again according to the strength required. The top tank is a large, egg-ended boiler, and is connected to each electrolyser by means of a rubber pipe and cock. It is from the top tank that the solution is pumped over to the bleaching mill, a distance of some 50 yards, by means of an 8in. centrifugal pump, where it is received in tanks, from which it is drawn as required. The method of working is very simple; the pulp ready to be bleached being in a potcher, the electrolyser bleaching solution is run in, and the washing drum kept working. As the solution passes through the pulp its bleaching power is exhausted, and it is returned, by means of a pipe, to the top tank, from which it originally started, and from whence it again passes through the electrolyser and is regenerated. The amount of solution remaining in the pulp after bleaching is recovered by a system of displacement in drainers or by means of a press plate. The current is supplied by three of Paterson and Cooper's Phœnix shunt-wound dynamos, each giving a current of 1,000 to 1,200 amperes, with a difference of potential at the terminals of 40 volts. The electrolysers are arranged in series, eight on each of two dynamos, and four on the other. This has been so arranged that another four may be added when required. Each circuit has an ammeter and voltmeter connected. The dynamos are driven by a compound condensing engine of the tandem type, capable of indicating 300 h.p., the amount actually taken up at present being 200 h.p. An important part of the plant is that for the preparation of the magnesia necessary for keeping the solution basic. It consists of a vertical tank fitted with a stirrer, in which lime milk is made. This is run from thence into a shoot, discharging into any one of three vertical tanks, each fitted with a stirrer. These tanks are all placed above the main tank supplying the electrolysers, so that by merely opening a cock the "base," when prepared, can be run down at will. The three vertical tanks are partly filled with a solution of magnesium chloride, and then filled to the top with the lime milk. The lime throws down the magnesia, the calcium chloride which

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remains is syphoned off, the magnesia being then washed twice is ready for use. The cost of bleaching by this system compares very favourably with the old process. The fibres bleached are not deteriorated in strength to anything like the same extent as with bleaching powder. There are many modifications of the process for the bleaching of linen and cotton yarns, piece goods, etc., and also many different forms of apparatus, which are the subject of numerous patents in the names of Messrs. Hermite, Paterson, and Cooper in England and abroad.

The plant has been manufactured and erected by Messrs. Paterson and Cooper, to whom we are indebted for this description and illustration, under the personal superintendence of Mr. Hermite. Several large paper manufacturers have adopted this process.

ELECTROLYSIS OF COPPER SALTS.

BY ALEXANDER WATT.

(Continued from page 35.)

16. *Nitrate of Copper.*—A bath was formed by dissolving 60 grains of the neutral salt in eight ounces of water, and the solution was electrolysed with the current from one cell, a pure copper anode and a steel cathode being employed as in the former experiments. Soon after immersing the steel plate it became coated with a film of copper, which, however, was only partially adherent. After a few minutes the anode was coated with a film of oxide, while a whitish salt floated in the liquid in flocculent particles, rendering the fluid turbid after a time. Two drops of nitric acid were now added to the bath, which immediately became clear from the white salt having become dissolved. No hydrogen was given off at the cathode. The nitrate of copper seems to be the best of the metallic nitrates for yielding to the action of the current, that is so far as deposition of metal is concerned. It was next determined to try if a stronger current, with agitation of the cathode, would cause the anode to dissolve more freely; but this modification of the conditions did not secure such a result, for it was found that the anode (which had been cleaned by dipping in hydrochloric acid) again became coated with an orange-yellow film of oxide. There was a moderate evolution of hydrogen when the two cells were used. A new solution of the nitrate, still more acid than the preceding, was next tried, but it was found that the anode only remained clean and bright at the two lower corners, while the remainder of its surface was coated with oxide. When this latter solution was tried in a very diluted condition, and the steel cathode kept briskly in motion, the deposited copper was found to adhere tolerably well.

17. *Nitrates of Copper and Potassa.*—Small quantities at a time of nitrate of potash were added to the foregoing solution, to see if this combination would favour the adhesion of the deposited metal to a steel surface. The result, however, was not satisfactory, for the various deposits obtained were less adherent than those obtained in the simple nitrate bath; at the same time the anode became strongly coated with a film of red oxide of copper, which attached itself firmly to the copper surface.

18. *Citrate of Copper.*—A solution of this salt was prepared by dissolving recently precipitated and moist hydrated oxide of copper in a strong and hot solution of citric acid. The liquid was then set aside to cool and settle, after which the clear liquor was poured off, and diluted with about twice its volume of cold water. A clean strip of steel immersed in this solution became promptly coated with copper, which was firmly adherent and of very good colour. The current from a single cell was then tried, when a steel plate received a prompt and very bright coating of copper, which, on being severely scoured with moist silver sand, proved to be very adherent. The brightness of the deposit from this solution might render such a bath useful for coating small fancy articles of steel or iron. On immersing a clean strip of zinc in this solution, it quickly assumed a yellow colour, owing to the deposited copper at once alloying itself with the zinc, forming brass. The same result was obtained when the current from one Daniell was used.

19. *Saccharate of Copper.*—A solution of this salt was electrolysed with the current from two cells, when a very tardy deposit was obtained upon steel, which was fairly adherent.

20. *Ammonio-nitrate of Copper.*—With the current from two cells, a bright deposit of copper slowly formed on a steel plate, which, however, was non-adherent. A bright green deposit formed on the anode, apparently hydrated oxide of copper, which, however, did not become dissolved in the liquid.

21. *Chloride of Copper in Hydrochloric Acid.*—Crystals of chloride of copper were added to an ounce of commercial hydrochloric acid, and the mixture stirred for several minutes, after which the liquid was poured off the undissolved salt and electrolysed with the current from two cells, the object being to ascertain whether a crystalline deposit could be obtained from this solution. Copper electrodes were used, and the moment these were immersed in the liquid a dark salt was thrown off from each electrode, which in a few seconds rendered the solution almost black. After a short time a spongy deposit of copper appeared at the cathode, which rapidly increased in bulk, but there was no disposition for the metal to assume a crystalline form in this concentrated solution. The solution was next diluted with about six times its bulk of water, and a platinum wire employed as the cathode, which soon received a spongy deposit of the metal, but beyond this no result of an interesting character was obtained.

22. *Pyrophosphate of Copper.*—A solution of this salt was prepared by digesting recently precipitated and moist carbonate of copper (washed in cold water) in a strong and warm solution of pyrophosphate of soda. The liquid was afterwards moderately diluted and electrolysed with the current from one cell, when a bright deposit of copper was received upon a steel plate. A solution prepared from this combination might be useful in cases where a bright deposit of copper is required. The anode kept very clean in this bath.

23. *Carbonate of Copper in Chloride of Barium.*—A solution was prepared by dissolving moist carbonate of copper in a strong solution of barium chloride, and the resulting solution, which was of a pale blue colour, was then diluted and electrolysed with the current from one cell. Deposition of copper took place very quickly, and the cathode (a steel plate) at first became coated with a bright film, but this after a few moments became dull and of a dark brown colour. The liquid had to be diluted very considerably, and the anode surface greatly reduced, before a uniformly bright film could be obtained; in fact, even when the liquid was diluted with at least eight volumes of water it was necessary to immerse only half a square inch of anode to a cathode surface of about four square inches. The deposit, under the modified conditions referred to, was exceedingly coherent, but after about 20 minutes' immersion the film assumed a dull appearance.

24. *Salicylate of Copper.*—A bath was prepared by digesting moist hydrated oxide of copper in a hot solution of salicylic acid, by which a liquid of a rich olive-green colour was produced. Electrolysed with the current from two cells, a deposit of copper slowly formed upon a steel surface. There was no evolution of gas, and the anode remained clean.

25. *Lactate of Copper.*—To form a solution of this salt, moist hydrated carbonate of copper was gradually added to lactic acid, in which it became freely dissolved in the cold. The resulting solution was afterwards moderately diluted with water, and then electrolysed with the current from a single cell, when it was found that a film of copper promptly formed upon a steel plate, which proved to be very adherent.

26. *Borate of Copper in Hydrochloric Acid.*—A quantity of borate of copper was first prepared by adding a solution of borax to one of sulphate of copper, and the resulting precipitate was then well washed. A portion of the precipitate was next dissolved in strong hydrochloric acid, and the concentrated solution, which was of a bluish-green colour, was electrolysed with the current from one cell, when dark brown spongy copper quickly formed on the

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cathode. At the same time a copious white deposit formed on the anode and dropped from the plate in solid flakes. Some of this white deposit was put into a test-tube filled with hot water, when it fell to the bottom of the vessel with great rapidity, and in its passage through the liquid turned to a full orange colour. A further portion of the white deposit was next washed in *cold* water, when it assumed the orange colour, as before, immediately on coming in contact with that liquid, which evidently altered its condition. The density of this substance, doubtless a suboxide of copper, was certainly remarkable. A small quantity of the white powder left in water for a few days acquired the red colour of the suboxide. The solution was next diluted with about six volumes of water; a strip of steel was then immersed in the liquid, when it quickly became coated with an adherent film of copper. With the current from one cell, the deposit was also firmly adherent, but turned dull after a time, and of a dark colour, having a purplish tone.

27. *Borate of Copper in Cyanide of Potassium.*—Borate of copper was added to a solution of cyanide of potassium, in which it became slowly dissolved. With the current from two cells a steel plate received a very tough and adherent coating of copper.

28. *Borate of Copper in Tartaric Acid.*—Borate of copper was gradually added to a warm and moderately-strong solution of tartaric acid, and the whole stirred until the copper salt was dissolved, when the solution, which was nearly colourless, was tried with the current from a single cell. On immersing a steel plate, it became at once coated with a film of copper, which very firmly adhered to the plate. The anode kept quite clean in this bath.

29. *Borate of Copper in Acetic Acid.*—A solution was prepared by dissolving the copper salt in strong acetic acid, the solution being afterwards diluted. In this solution a strip of steel slowly and slightly became coated with copper by simple immersion. With one cell, the deposit was still slow, and the film non-adherent. Two cells were next tried, when deposition was somewhat quicker, but the plate only became coated in parts, with, however, a very bright film, more especially at its outer edges, where the metal was as bright as if it had been burnished. The anode kept perfectly clean in this solution.

30. *Ammonio-sulphate of Copper.*—This salt was prepared by the pharmaceutical method, equivalent proportions of copper sulphate and ammonia carbonate being triturated together in a mortar until carbonic acid ceased to be given off. A moderately-strong solution of the salt was then made, in which a steel plate received no metallic deposit by simple immersion, neither could any deposit be obtained with the current from a single Daniell. With two cells, however, a deposit of copper slowly formed upon a steel plate, which was very adherent. As in the case of the ammonio nitrate solution, a bright green deposit formed on the anode.

31. *Oxide of Copper in Ammonia.*—A quantity of hydrated oxide of copper was digested in strong liquid ammonia, and the solution afterwards moderately diluted with water. With the current from two cells, copper slowly deposited on a steel cathode, but this was only adherent in patches, the remaining portions of the film becoming readily detached by scouring with silver sand.

32. *Carbonate of Copper in Carbonate of Ammonia.*—Moist carbonate of copper was digested in a strong solution of sesquicarbonate of ammonia, and the resulting blue solution was first electrolysed in its concentrated condition with the current from a single Daniell, when a bright and fairly adherent deposit slowly formed on a steel plate. The solution was next diluted with about three volumes of water, when it was found that with the same current deposition proceeded somewhat quicker. With two cells and small anode surface, the copper deposited very quickly, the cathode being kept in motion for a few moments and then allowed to rest undisturbed for about 10 minutes. On scouring the plate with sand at this time, the coating was found to be more adherent than under the previous conditions. There was no deposit on steel by simple immersion in this solution, but a strip of zinc placed in the liquid slowly became coated with an adherent film of copper, the metal retaining its reguline condition even after the zinc plate had been immersed for a considerable time, there being no tendency for the metal to go down in a spongy state. With the current from a single cell a plate of zinc promptly received a coating of copper, which adhered firmly to that metal. During the electrolysis the anode kept perfectly clean.

33. *Carbonate of Copper in Bisulphate of Potassa.*—A bath was prepared from this combination by digesting recently-precipitated carbonate of copper in a strong solution of bisulphate of potassa (*sal enixum*), the resulting solution being of a pale blue colour. With the current from a single Daniell a very quick deposit of copper of good colour was obtained upon a steel plate, but this was only partially adherent. The solution was next diluted with a moderate proportion of water, when it was found that deposition still took place too promptly for an adhesive coating. It was therefore further diluted with increasing proportions of water, with a view to induce the copper to adhere to the steel. After many trials, however, this condition was only partially accomplished, and after the plate had been some time in the bath the deposit blackened at the lower corners and edges of the cathode, the film at such parts being more or less non-adherent. A strip of zinc immersed in this solution reduced the metal in the form of a dark non-adhesive powder. A solution was next prepared by dissolving hydrated oxide of copper in a strong solution of bisulphate of potassa, but this electrolyte, even when considerably diluted, failed to yield a perfectly adherent deposit of copper. On examining the anode, it was found to be coated with a yellow film of suboxide.

34. *Hyposulphite of Copper.*—Moist carbonate of copper was digested in a strong solution of hyposulphite of soda, the resulting liquid being colourless. The solution was first tried in its concentrated condition with the current from two cells, when a slight film of copper deposited upon a steel cathode, but in a short time this electrode became coated with a loose, dense, black deposit, and the liquid became discoloured. The solution was next diluted with water, when the copper deposited slowly, as before, but the metal adhered well to the steel plate. After about 20 minutes' immersion, however, the black deposit again formed. A strip of zinc immersed in the solution received a coating of copper, which at once alloyed itself with the zinc, forming a yellow coating of brass. The anode was found to be coated with an adherent layer of red suboxide of copper.

35. *Borate of Copper in Sulphate of Alumina.*—A solution was formed by digesting recently precipitated borate of copper in a strong solution of sulphate of alumina, and the resulting liquid, which was of a pale blue colour, was afterwards diluted with water. With the current from two cells, a film of copper quickly formed upon a steel plate, but after a short immersion the deposit assumed an iridescent appearance—more especially on the side facing the anode. The anode surface was then reduced, and a fresh plate immersed, which was kept briskly in motion for some time, under which conditions a bright film of copper was obtained, but when the cathode was allowed to remain stationary for a few minutes the coating assumed a nearly black colour, and was readily removed from the plate with very light scouring.

36. *Arsenite of Copper in Cyanide of Potassium.*—This solution was prepared by digesting arsenite of copper in a strong and warm solution of cyanide of potassium, and the liquid afterwards diluted with water. With the current from two cells, arsenic alone deposited upon a steel plate when it was allowed to remain stationary, but when kept in motion copper also was deposited, forming a doubtful alloy of a yellowish tinge, but this did not adhere to the plate.

37. *Oxide of Copper in Sulphate of Soda.*—Moist hydrated oxide of copper was added to a strong and warm solution of sulphate of soda, and the mixture well stirred until the oxide was dissolved, the solution being afterwards diluted with water. With the current from one cell, an adherent film of copper was received upon a steel plate, which, however, turned black at the corners after a short immersion. When the solution was further diluted, and only a small surface of anode exposed, the film at first appeared bright

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and of good colour, but after a time it assumed a mottled appearance. A strip of zinc immersed in this solution became coated with a dense black non-adherent film.

38. *Copper Carbonate in Tartaric Acid.*—Recently precipitated carbonate of copper was digested in a hot solution of tartaric acid, the resulting liquid being colourless. A strip of steel immersed in this solution, when cold, slowly became coated with copper. With the current from one cell, a steel plate received a film of copper soon after immersion, the deposited metal being very bright and adherent. A strip of zinc immersed in the liquid for some minutes became coated with a film of a golden-yellow colour, from the deposited copper having alloyed itself with the zinc. This yellow film, however, was easily scraped off the plate with the finger-nail.

39. *Copper Carbonate in Citrate of Ammonia.*—Small quantities at a time of moist carbonate of copper were added to a cold solution of citrate of ammonia, and the resulting solution, which was of a deep blue colour, was electrolysed with the current from one cell, when a steel plate received a prompt and bright deposit of copper, which adhered to the plate with great tenacity. By simple immersion, there was a slight tendency for the copper to deposit on steel after a few minutes; but a strip of zinc readily became coated with a bright and very adherent film of copper.

40. *Oxichloride of Copper in Hydrochloric Acid.*—A small quantity of strong hydrochloric acid was neutralised with recently precipitated and moist oxichloride of copper, and the solution then diluted with a considerable quantity of water. The solution, which was of a pale bluish-green colour, was electrolysed with one cell, when a film of copper slowly formed upon a steel plate, but the metal was non-adherent. In this bath, steel became coated by simple immersion, but the film, as before, was not adherent.

41. *Sulphate of Copper and Potassa.*—This solution was formed by dissolving hydrated oxide of copper in a warm solution of bisulphate of potassa, the resulting solution being of a greenish-blue colour. The solution, when cold, was tried with one cell, when a plate of steel received a bright but not very adhesive coating of copper. The liquid was then diluted with a large bulk of water and a fresh plate immersed, which was kept briskly in motion, when a fairly adherent film was obtained; but on the plate being allowed to rest undisturbed for a few minutes, it was found that the coating assumed a deep black colour, the deposit being easily detached by rubbing with the finger. The solution was next further diluted, and a smaller anode surface immersed, but the deposit, though somewhat improved in character, eventually acquired a very bad colour and a mottled appearance, the film being readily removed by scouring with sand.

42. *Oxichloride of Copper in Bisulphate of Potassa.*—A bath was formed by digesting moist oxichloride of copper in a strong solution of bisulphate of potassa in the cold for some hours, when a blue solution was obtained, which was afterwards diluted and electrolysed with the current from a single Daniell, when a dark-coloured deposit slowly formed upon a steel surface, which, however, was tolerably adherent. When the cathode was allowed to remain stationary, the film soon became still darker in colour, and this was not much improved by further dilutions of the liquid.

(*To be continued.*)

THE TELEPHONE IN SWITZERLAND.

The returns published by the Swiss Confederation with reference to telephonic communication in Switzerland show that since the establishment of the first telephone, in 1880, 61 towns have been provided with it, and there are now 6,944 telephonic stations, of which no fewer than 1,500 are in Geneva and its suburbs. Most of the Swiss towns are now connected with one another, Geneva communicating not only with Lausanne and other places on the shores of the lake, but with Berne, Zurich, and St. Gall. The Confederation has taken over the telephones, which are attached to the Department of Posts and Telegraphs, and the annual cost of subscription is only £6. Notwithstanding this moderate charge, the receipts exceed the expenditure by about £8,000, and the Federal Council now contemplates reducing the rate of subscription to £5 for the first year, £4 for the second, and 80f. for the following years, with a trifling supplemental charge for those subscribers who use the instrument more than 500 times during the twelvemonth.

NOTES ON THE DESIGN OF ELECTRIC MOTORS.*

BY ALBION T. SNELL.

In discussing the design of electric motors, it will be necessary to, first of all, consider the relation between the dynamo and the motor. The dynamo may be defined as a machine which converts mechanical work into electrical energy. The motor, when supplied with electrical energy, gives out mechanical work. So far, one is the converse of the other, and the dynamo is said to be a *reversible* machine.

The extent to which this is true depends very largely on the size of the machine under consideration. This follows from the fact that no matter how bad the design of motor, how weak the field, or how small the magnets or armature, it is sure to *run*. But a badly designed dynamo—one with relatively weak field-magnets say—will often not excite at all. Or, again, the proportions of armature and field may be relatively correct, but the mass so little that the like result obtains. Why is this, if the dynamo be a reversible machine? It has been shown that the reactions in the dynamo armature are not the same as those in the motor. And it is now generally admitted that the effect of self-induction in the dynamo armature is to increase the lead, while in the motor it tends to diminish it. And Mr. Mordey has pointed out that in the generator the effects of self-induction in the armature windings are opposite to those of the Foucault currents in the core; but in the motor they tend to increase each other.

The writer has had these differences brought under his notice very forcibly in the course of his experience, having been connected directly or indirectly with the design of more than 400 machines, varying in output from 1 h.p. to 100 h.p., and from 20 watts to 70,000 watts.

The chief cause of this difference between dynamo and motor is to be found in the mutual effects of armature and field. Profs. Ayrton and Perry so far back as 1883 showed, both mathematically and practically, that in the motor the magnetism of the armature and that of the field *might* be added; in fact, the motor effort is proportional to the magnetic strength of both armature and field-magnets, while in the dynamo the field due to the armature, considered as an independent magnet, must necessarily subtract from that of the magnets. These main distinctions occur in the nature of things. Their magnitude at first seems to be considerable; but really the effect depends very largely on the actual dimensions and the relative proportions adopted.

An ideal dynamo has an armature with neither internal resistance nor magnetism *per se*. The field-magnets alone are the source of lines of force. This condition may be the more nearly attained as the size and weight of the machine be increased. All text-books tell us that the field-magnet should be as powerful as possible, and the armature relatively weak. The exponents of the "reversible theory," and its carollary, "the better the dynamo the better the motor," appear to have had more experience of large machines than small ones. And their *experimentum crucis* necessarily leads them to such views. When such authorities as Hopkinson and Silvanus Thompson, Kapp and Mordey, assert anything electrical, few venture to disagree. But I beg to submit that an extended experience with small and medium size machines would modify their views, especially if weight-efficiency be an object in the design.

Be this as it may, a motor weighing 70lb. can be made to give a b.h.p. with 70 per cent. efficiency of conversion; but the same machine run as a dynamo would require nearly 50 per cent. more speed to give an output of 746 watts, and even then the efficiency between output and belt-power would be nowhere near 70 per cent. If this be true, and I think it beyond dispute, the theory and corollary require some modification. The approximation to the same efficiency when used as a dynamo or motor becomes the more apparent as the size of the machine is increased; but even up to 50 h.p. I prefer to make certain structural differences in the design of dynamos and motors, particularly if they be series-wound. With shunt machines the difference seems to be less marked owing to the field being nearly constant. If I mistake not, both Hopkinson and Mordey have founded their opinions on observations made from large shunt machines.

Much more might be said on this branch of the subject, and numerous actual experiments might be given in support of my views, but this would digress too much from the object of this paper. With these introductory remarks on the character of motors and their relationship to dynamos, I will pass on to the general design of motors.

There are two broad lines on which motors can be designed. They depend entirely whether weight and overall dimensions enter into the problem. It is only necessary to admit that a powerful armature with many ampere-turns and a relatively weak field will give the same torque as a strong field and a weak armature. Granting this, we can design a motor to give a certain torque independently of the total weight to some very considerable extent. We shall be guided in the proportion of armature and field by the work expected of the motor, by the price allowed for production, by the intended cost of future

* Paper read before the City and Guilds of London Institute Old Students' Association, January 16, 1889.

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maintenance, and by the desired life. These two methods of design depend on the point of starting. In the *first* we take an armature of given size, select a certain surface velocity, and build the field as small as possible to give the desired torque. In the *second*, a certain type of field iron being determined on, we select an armature of sufficient cross-section to give the required results. The first of these two methods is by far the more scientific, inasmuch as the dimensions of the most costly part of the motor can be made a minimum. The second method, however, will sometimes occur in practice, and it is well to note the possible results of this as well as those of the more general case.

When designing a motor to do particular work the following points should be considered:

(1). What is likely to be the average torque on the motor and driven shaft?

(2). Is the motor to run continuously or only for short periods at more or less frequent intervals?

(3). What variations of load may be expected?

(4). What will be the maximum torque on the motor shaft?

(1) and (4) will determine the characteristic of the motor and the particular part of the curve at which the average torque shall be arranged to fall.

(4) will determine the size of the shaft and strength of the bearings.

(1) gives us the ratio of the speeds between the motor and the driven shaft.

(2) and (3) determine the limiting safe rise of temperature,

While the winding must be designed to satisfy all the conditions as nearly as may be.

It is not possible within the limit of a short paper to thoroughly analyse the different points to be observed. The general method can alone be indicated, and experience must teach the engineering student the rest. I will roughly run through the several conditions of design, and give such hints as appear likely to be of use.

Richmond, United States. That the method is unsatisfactory and can be much improved on there is no doubt, for Mr. Sprague has already (October 2nd, 1888) published drawings of a new tramcar involving two motors with *countershafts.*

Engineers using electric motors seem to forget that a motor, although very efficient at or about a certain speed, is most inefficient at low speeds (*vide* Fig. 1).* Too much stress is laid on the property of a motor exerting a maximum torque at starting. It is forgotten that the efficiency is *nil* under the condition of maximum torque, and that it increases very slowly until the point of 50 per cent. is reached. There are other sides, of course, to the question; but I wish here to strongly emphasise the primary condition of motor design—viz., attention to the torque of motor and main shaft.

Having then determined the torques of the system, the ratio of our gearing is known. Let us suppose that the motor torque be $\frac{1}{10}$th that of the main shaft, and that the gearing be accordingly in the ratio of 1:10. We have now to select an armature that will give us this torque at the speed required, satisfying also the conditions of durability, and that the rise of temperature will not exceed a certain limit—say 60deg. F., above the temperature of the room.

The mathematical expression for the torque of a motor is simple.

Let T be the torque. The output required of the motor at n revolutions per minute is, say, 1 b.h.p.

Then $$T = \frac{B.H.P.}{2\pi n} = \frac{33,000}{2\pi n} = \frac{5,280}{n} \text{lb. ft.} \quad (a).$$

That is, the moment of the forces tending to turn the armature is equal to $\frac{5,280}{n}$lb. acting at a radius of 1ft.

To get the exact pull on the periphery, it will be necessary to multiply this quantity by the ratio $\frac{1}{r}$, where r = the mean radius of the armature in feet.

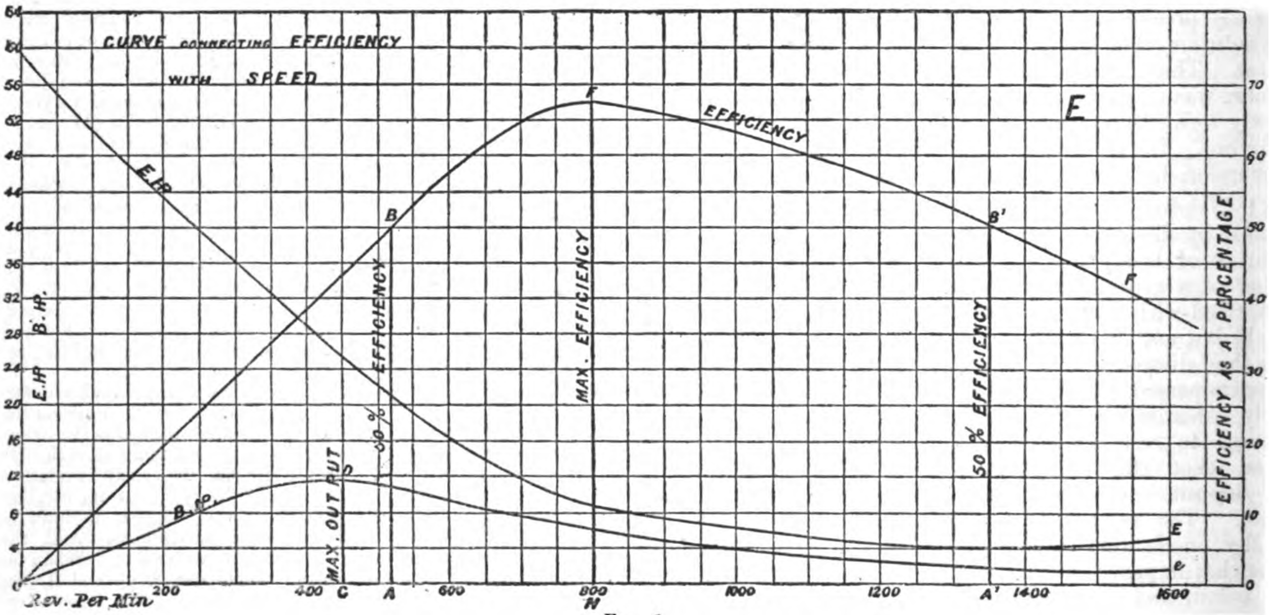

Fig. 1.

The first thing to be noted is the torque on the driven shaft. This is not always an easy thing to get at owing to the want of a little scientific nous in the ordinary mechanic. If, however, this be known, it is possible to determine within a few per cent. the required current, and the best ratio of gearing to get a maximum average efficiency from the motor. If this be accomplished, the motor will be a success. If the motor be designed on the assumption of so much horse-power being required, and gearing be accordingly selected, it probably will happen that, though the estimate of power be fairly correct, the motor will be unsuited to the work. The current, and consequently the torque on the motor-shaft, will probably be excessive. The efficiency of the motor will thus be low, and the e.h.p. absorbed excessive, while, further, the speed will be too slow. The obvious remedy would be an increase of the ratio of the intermediate gearing; but if the surface velocity of the motor be correctly designed the increased speed will be too great, and, consequently, introduce other difficulties; in fact, the motor will be a failure—not from any intrinsic fault, but simply because improperly designed for the work.

Daily one comes across machines driven by electricity, steam, air, or water, in which the same fault appears. The speed of the prime shaft is not properly proportioned to that of the main or driven shaft. The consequent loss in possible efficiency is oftentimes not known, or, if suspected, is ignored. This sort of thing did well enough years ago; but addressing a body of educated men who are likely to occupy leading positions among the engineers of the immediate future, I cannot pass it by without protest. I therefore beg to impress on you the necessity of determining in some way or other the actual number of foot pounds required to make one revolution of the main shaft. Your ingenuity will suggest many ways of doing this in most cases.

As an illustration of my point, I will mention the many attempts to run electric tramcars by direct gearing, *i.e.*, without a countershaft. Nearly every firm that has tried the tramcar problem has made the attempt. The last has been the Sprague motor line at

The tangential strain on the wire is therefore

$$= \frac{5280}{n} \cdot \frac{1}{r} \text{lb.} \quad (\beta)$$

This latter quantity is what we require in designing the motor. In order to obtain the desired couple on our armature, we make $T = \frac{Z_a N t C_a}{2\pi}$ (γ), where Z_a = the number of lines of force passing through the armature, $N t$ = the number of turns of wire counted all round, C_a = current flowing in any one coil of the armature—*i.e.*, half the total current—and r = mean radius of the armature core. It will be noted that the field does not come directly into the question. The function of the field-magnets is only to supply a magnetic field. It will be our care to so arrange the magnets and their windings that the proper value of Z_a is obtained. This is all that is necessary now. I shall have occasion to comment on this assumption later on when considering the field.

We have now to determine the values of Z_a, $N t$, and C_a.

C_a will usually be given us by the condition of supply and the horse-power required.

Z_a can be determined from the equation $Z_a = 2 a b z$ (δ), where z = lines per square inch, a = depth of core in inches, b = the length of armature *less the insulation* in inches.

Experience alone can tell us the best shape and size of armature core, but since the total cross-section ($= 2 a b$) is known no great difficulty presents itself. The depth of core will be mainly determined

* Curve E E is the value of the e.h.p. for the different speeds, the motor running at constant potential. O e is an approximation to the corresponding b.h.p.; and O F F is the commercial efficiency (plotted to another scale). It will be noted that the efficiency increases at first with the speed, and, after attaining a maximum, slowly decreases, having passed through two points of 50 per cent. efficiency.

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by the style of winding and the value of T. For a small torque, a small armature and a large number of revolutions will be chosen ; for a large torque, a large, slow-speed armature is required. It will be necessary to note that a large cylinder or ring armature of short length is equivalent to a long drum of smaller diameter.

Then, assuming that the core be chosen, a, b, and r are known. It only remains to substitute these values in (γ) and solve for $N\,t$. If the quantities are properly chosen, $N\,t$ will have such a value that for a suitable current density the depth of winding will be about 10 per cent. of the core radius for cylinders and 15 per cent. for drums.

If the value of $N\,t$ be not a rational one, the dimensions of the core must be altered. A few trials will illustrate this important part of the design, but practice alone can give ease and certainty.

In actual practice the matter is much simplified by previous experience and by fixed sizes of cores. It is then customary to select a wire to suit the current given, and to vary the speed so as to make the magnetic density suitable for the work. This is the crucial part of the whole thing. In other words, the motor is designed to give the required torque at a certain part of the characteristic. This point varies with the shape of the curve and with the conditions of work expected. My meaning will be more easily seen when the field-magnets have been discussed.

The best relative dimensions of armature and field cores is an open question. This is apparent from what has already been said. It depends entirely on the object aimed at. If weight efficiency be the desideratum, the armature *must* be relatively powerful, and the cross-section of the cores may be made equal, allowing, of course, for the different permeabilities of the iron used. But if cheapness be the principal object, then a heavy field and a small armature are necessary. Speaking generally, the field strength has to be *relatively* greater as the size of the machine is increased.

The design of the motor field presents some considerable difficult to the student. There are so many shapes and forms in vogue, and the same end seems to be attained with such opposite forms. With few exceptions, too, even old-established firms are continually changing their patterns, often with no apparent effect other than a weakening of the public confidence, and a considerable needless expense. Indeed, the engineering draughtsman seems to be at his wit's end to bring out a new design. Yet there is really no ambiguity on the subject. Text-books tell us the best form of magnet is that, *cæteris paribus*, which offers the least magnetic resistance, with a maximum cross-section and a minimum perimeter. Theory then points to a horseshoe magnet, of circular form and round cross-section. Difficulties of construction, however, render this ideal form too costly, and the matter has to be compromised. It is to this endeavour to balance the advantages of theoretical indication with the necessities of engineering that we owe the numerous types of fields.

The design of the field is, however, not so important with the motor as with the dynamo, and a little consideration will enable the student to determine suitable proportions.

In the first place, the field has to supply a certain number of lines of force to the armature, or is expected to form poles of such strength that, in conjunction with those found in the armature, the necessary torque will be obtained. If gross weight be neglected, and a minimum expenditure of copper be desired, the single horseshoe is chosen. Such machines are common enough, and may be made vertical, horizontal, or inverted. The two first types are the better, since the leakage is less. If a light-weight machine be required, even at the expense of copper, then double horseshoe magnets are used. This type involves twice the number of ampere-turns to give the same strength of pole as the single magnet does ; but yet it has considerable advantages. The resultant magnetic field is likely to be more uniform, and less trouble is given by the brushes as a rule. If the armature be of a large diameter—say more than 24in.—it is better to have a four-pole machine, although the ampere-turns will be double that required with a double magnet, and four times that with a single one, if the same value of Z_a be taken. The Oerlikon dynamos, for the reduction of refractory ores, are made with six poles, and no doubt a more even distribution of magnetism is gained.

Having selected the form of magnet, the question of length and cross-section of limb arises. Here the criterion is simply sufficient space to wind the wire necessary to give the desired strength of poles and area enough to carry the magnetic flux required.

Here the student finds the first real difficulty. Let us review the position. We know the E.M.F. of supply or the allowed number of volts. The current is also approximately known from the b.h.p. and the assumed efficiency of conversion. The torque of the motor has been determined and expressed in terms of the magnetic flux through the armature iron, the effective cross-section, and the number of turns of wire. The dimensions and shape of the core are also agreed upon. So far it is a physical certainty. The problem now, primarily, is to design a field-magnet which, in conjunction with the armature, will give the required number of lines in the armature core. This is strictly all that is necessary. The question of economy of material and labour spent in the building of the field-magnets cannot be discussed here.

The magnetic flux in the magnets, to give a particular value of Z_a, I believe to be unattainable by direct calculation. Let Z_1 be the total lines induced at S in a single horseshoe magnet, and assume the lines to pass through the yoke Y and enter the armature at N (Fig. 2). The leakage which occurs all along the windings, and on the neutral part or yoke, reduces the value of Z_1 to, say Z_2. But Z_2 is still further lessened by leakage of lines from N to S outside of the iron or copper of the armature, and the effective number of lines is reduced to, say Z_3. Now, the ratio of $Z_1 : Z_2 : Z_3$ will vary according to the shape of iron, the length of cores, the contour of the winding, and the average density of magnetism. The problem is already sufficiently complex, but yet this is not all. We have yet to take into account the useful number of lines induced in the armature by its own windings = say, Z_4. This quantity is usually ignored in text-books, but I know from a large number of experiments, that if we wish to be accurate in our treatment of the subject, this factor must not be neglected. I cannot go into figures, but the

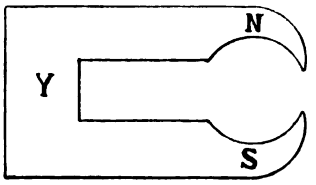

Fig. 2.

importance of the motor-armature, considered as an independent source of magnetism, may be understood from the following considerations :

Take a large series machine designed as a dynamo, having a relatively powerful field and weak armature. Let this be run at such a speed and output that the top of the straight part of the characteristic is just reached. Observe the speed, current, and terminal E.M.F. Then drive it as a motor, using the same number of volts on the terminals, and load the brake till the same value of the current is attained. The speed will usually, I think, be found to be nearly as great as that required as a dynamo.

Next take a smaller machine, designed as a motor—*i.e.*, one with a relatively weak field, etc.—and repeat the experiment. It will probably be found that for the same values of current and terminal E.M.F. the motor speed will be considerably *lower*.

This variation in the two speeds is due partly to the lead required in different machines when run as dynamos or motors, and also largely to the relative importance of the armature magnetism. Two simple equations will assist the study of the problem. Neglecting friction, let

E_d be the internal E M.F. of the dynamo.

$E_m = \dfrac{\text{B.H.P. } 746}{c}$ be the internal E.M.F. of the motor.

E_T be the terminal E.M.F. both of dynamo and motor.

C R be the volts lost over the internal resistance of the machine.

L_d be the value of the reactions of the dynamo armature.

L_m be the value of the reactions of the motor armature.

It will be necessary to note that L_d and L_m will vary with the lead required.

For the dynamo we have—

$$E_d = E_T + (C\,R + L_d) \quad . \quad . \quad . \quad . \quad . \quad \text{(I.)}$$

For the motor we have—

$$\frac{\text{B.H.P. } 746}{c} = E_m = E_T - (C\,R + L_m) \quad . \quad . \quad \text{(II.)}$$

Now, the speed of the motor varies as E_m, and the speed of the dynamo varies as E_d. It follows, then, that the motor speed should be *less* than the dynamo by a quantity proportional to $(C\,R + L_d) + (C\,R + L_m) = 2\,C\,R + L_d + L_m$. If the speed of the motor be *greater* than that given by these equations, L_m, the only quantity that can possibly be varied, must be a factor of importance and, moreover, of *negative sign*. This means that, in the motor, the armature adds magnetism to the resultant field, and thus increases the value of E_m, and, consequently, raises the speed. In the limit $L_m = C\,R$ and $E_T = E_m$—*see* (II.). Even if these values were possible in practice, E_m would be still less than E_d; so that the relative values of the speeds can only be seen by examination of the ratios $\frac{E_m}{n_m}$ and $\frac{E\,d}{n_d}$. It will be found with all normal machines that $\frac{E_m}{n_m}$ is less than $\frac{E\,d}{n_d}$. One must not confound the question of efficiency with these experiments. The efficiency of a dynamo for a given E.M.F. and current varies *inversely* as the speed, for the torque is clearly proportional to some function of the current, and is nearly independent of speed. The motor efficiency for the same electrical constants varies *directly* as the speed. In fact, we endeavour to make the dynamo speed a minimum, and the motor a maximum.

In the first experiment, say, in a large Edison-Hopkinson dynamo, the efficiency either as dynamo or motor will not differ much, but I should expect the motor to give the better result by a small percentage. The influence of the armature is relatively small, and the lead very little. The only objection to the machine, considered as a motor, is the weight, and, consequently, increased cost of material for a given output.

In the second experiment the armature is large compared with the field. Hence, the lead as a dynamo will be great—probably 30deg. at least in a positive direction ; as a motor, the lead, if any at all, will be much less, perhaps 5deg. in the negative direction. The machine will be inefficient as a dynamo, and require a high speed ; but as a motor it will be *much more* efficient, though the speed will not be so great as that required for the dynamo. The second machine will be a good motor—efficient light, and cheap.

This explanation is very rough, but it will help to explain the reason for considering the armature as an independent magnet in motor design. The Oerlikon plant, described in the technical press some six months ago, illustrates the point. The dynamo and motor have armatures identical both as regards the mass and distribution of iron and copper, but the motor field has 7 per cent. less copper and iron than the dynamo, and I know of many installations where proportionately much smaller motor fields are used with advantage.

Many attempts have been made to predetermine the characteristics

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of dynamos and motors; yet the best seem to be but approximations. From what has already been said, it follows that the difficulty only lies with the number of lines of force in the field. This quantity is indeterminate, chiefly because we have no magnetic insulator. We can get the characteristic of the iron of both field and armature, and we know the resistance of the air space. But we do not know, and cannot as yet predetermine by calculation, the loss of magnetism which will take place over a new type of machine. Mr. Kapp has shown that this leakage is a function of linear dimensions of the machine, and hence varies with every type; indeed, no matter how small the alteration in design the value of the lost magnetism is changed. Practically this presents no difficulty, as only a few types obtain with most firms, and a few simple experiments will determine the number of ampere turns to give any desired result.

Dr. Hopkinson and Mr. Kapp were, perhaps, the first to move in this direction of calculating the ampere turns required in the field to give a definite magnetic flux in the armature. Both methods are well known, but a brief reference will assist us to follow the subject. Mr. Kapp started from a geometrical treatment of the design, and assumed the magnetic resistance of iron to be expressed by a law similar to that of Ohm, and the saturation effect was assumed to follow a tangent function. I have used the Kapp formulæ for many machines, both dynamos and motors; indeed, I think I was probably the first to apply them to motors; but the results are not satisfactory, particularly with large machines. The equations do not take into consideration the leakage in a sufficiently accurate manner, and the ampere-turns have to be increased from 25 per cent. to 100 per cent. above the value given by calculation. The characteristic thus obtained usually rises too slowly, and after cutting the real curve about the point of half-saturation of the field-magnet, does not fall sufficiently rapidly. My experience, I believe, is fairly well borne out by other users of the Kapp formulæ.

Hopkinson starts on a different basis. He determines experimentally the curves of saturation of both field and armature iron, and expresses the magnetic flux in terms of absolute magnetising force ($4\pi S i$) per centimetre length of core. The specific resistance of air is also determined by experiment. So far this is perfectly safe ground. But the characteristic of the machine itself is the summation of the curves of the field and armature iron and the air space, modified by the leakage and the reactions of the armature. Hopkinson has now to resort to experiment to find the magnitude of these disturbing influences, and a good deal of approximation or experimenting is required. Indeed, the method is not applicable to a new type of machine without considerable knowledge of the subject.

Prof. Silvanus Thompson, in the third edition of "Dynamo-Electric Machinery," gives a method combining both Hopkinson's curves and Frölich's equation:

$$N = N_1 \frac{S i}{S i + (S i)_1}.$$

N = maximum number of lines in the field-magnet.
N_1 = lines in field-magnets to give the diacritical value.
$S i$ = ampere-turns to give N.
$S i_1$ = ampere-turns to give N_1.

But this, again, demands an experimental determination of the leakage coefficient, and does not seem to me to advance the subject much.

Mr. Esson employs a modification of Dr. Hopkinson's method. Using the saturation curves of the iron and specific resistance of the air as his starting points, and selecting a definite value of Z_a, he determines the number of ampere-turns per centimetre of magnet core to give this value in the armature, neglecting leakage or self-induction. With a known type of machine this method presents great advantages, for the field-winding is given by simple reference to the curves.

Fortunately for us practical men, there is no pressing need of an exact mathematical solution. With a known type of field, machines of any output can be designed with certainty from previous experience and easy applications of the rule of three.

It may be noted that the slope of the characteristic is mainly determined by the resistance of the air gap. The curves of the field and armature iron do not largely affect the general shape till the diacritical points of either be reached. If the field be so crowded with wire that this point be passed, then the characteristic of the machine will bend rapidly.

Before leaving this part of the subject, I will briefly examine the question of pole-pieces.

Judging from the variety of shapes of polar extensions obtaining in machines in the market to-day, there seems to be no little ambiguity on the subject. Some makers use long poles, extending over nearly 160deg. of the armature periphery. Others cover 90deg. to 100deg. Some machines are to be found with long, thin, sharp extensions, whilst some have short, thick, and rounded ends. Each in its way accomplishes a particular end, but only want of knowledge could lead to the extreme proportions sometimes met with. This variety of dimensions in the pole-pieces and extensions arises from an attempted compromise between theory and simplicity of design.

Theory, on the one hand, points to an extended pole-piece if a low magnetic resistance of the air gap be desired. But since there is a tendency for the magnetic density to increase at the extremities of the poles, an undue lengthening of the arc encircled leads to a distortion of the main field. And, further, the position of commutation becomes a line, whilst really there should be some two or three segments on either side on which the brushes may rest without causing sparking or heating of the coils short-circuited beneath them.

Theoretical considerations, then, compel us to shorten the polar extensions, although we thereby raise the total magnetic resistance. This involves, however, no practical loss, for magnetism is cheap, and a few more ampere-turns will compensate for the weakened field.

It is curious to note how the tendency to shorten the pole-pieces has increased during the last 12 months or so. The Manchester dynamo used to have pole-pieces extending over 139deg. I heard the other day of a Manchester machine with poles not more than 90deg. in length. Messrs. Paterson and Cooper are also making both dynamos and motors with short poles; so are many other firms.

In some designs there are practical reasons for shortening the poles. If the cores are vertical, it is a convenience to be able to slip the windings over the poles. To attain this, the cores are prolonged and the poles bored out of them, instead of being built up of separate castings. This is applicable to both cast and wrought iron magnets.

Rounded polar extensions are also used in some designs, particularly with high-tension machines. I think this was first done in the Weston dynamos. Speaking generally, for motor pole-pieces I would recommend that the arc embraced be not more than 120deg., preferably rather less, and that the poles be rounded at all their extremities. The section of the poles should vary about in proportion to the magnetic flux desired. By a careful attention to this point the field may be properly spread over the whole of the coils beneath the poles, and the E.M.F. induced per coil be approximately the same. This is a matter of no little importance in large machines.

The best way of testing the activity of the different coils is the one first used by Mordey, I believe. By a simple arrangement of two movable brushes, the E.M.F. of coils in different parts of the field is successively measured and the result plotted. This gives the differential curve of potential. From this the integral curve may be obtained, or a direct experiment will give the same result. Fix one lead of the voltmeter to, say, the negative brush, and move the other in contact with the commutator through spaces equal to the angular width of one coil, taking readings at each space. These two curves show at a glance the relative activity of the coils and the distribution of the main field. No better method can be devised for showing the exact action of the armature, and the relative advantages of differently shaped poles and polar extensions are at once apparent.

This method is also very useful for showing the difference between the distribution of magnetism in the dynamo and motor field. I have derived considerable assistance from an exhaustive treatment of different machines in this manner. The results obtained are very curious, and serve to explain why it is advisable to make a difference between machines used as dynamos or as motors.

Generally motors are likely to have greater and more sudden variations of load than dynamos, hence the necessity for extra care in designing the pole-pieces. The principal point to be aimed at is to make the position of commutation sufficiently large for the variations likely to occur.

Assuming we have now designed and built our motor on the lines discussed here, it will be necessary to examine the degree of excellence attained. This is best done by brake tests. It will not be necessary to run the motor at a constant potential; indeed, in practice this is often a matter of no little difficulty. Let our motor be series-wound, and designed to run on a lighting circuit of 100 volts. Measure the ohmic resistance hot. Arrange the motor with a Prony or other absorption brake, and put a suitable resistance in series with the windings, so that any desired E.M.F. may be obtained within the limits of supply.

First, run the motor light—*i.e.*, without the brake, at the highest speed required of it, and note the terminal volts and the amperes. Then place the brake in position and screw down the blocks. Take readings with different loads, varying the current by intervals of one ampere, and noting the corresponding volts and speeds. When the maximum load is reached, we have all the data for calculating the performance of our motor. Arrange ten columns with following headings:

Speed.	Weight	Volts.	Amp.	B.H.P.	E.H.P.	Efficiency.	$\frac{E}{n}$	$\frac{e}{n}$	$\frac{\text{B.H.P. } 746}{n c}$

The first four are filled in from the observations of the test. The b.h.p. is calculated from the speed, the brake load, and the brake constant. The e.h.p. and the efficiency speak for themselves. We have now three columns left. From these we purpose to plot three curves that will show how far our method of design is successful.

The first, $\frac{E}{n}$, is the terminal E.M.F. divided by the speed obtaining for the particular value of E.

The second, $\frac{e}{n}$, is the so-called back E.M.F. ($= E - C R$) divided by the same value of n.

The third, $\frac{\text{B.H.P. } 746}{n c}$, is really of the same order—viz., a definite number of volts absorbed per revolution *in actual work on the brake.*

This requires some explanation. Note that the b.h.p. multiplied by 746 gives the available useful h.p. in watts, *i.e.*, a quantity that can be expressed by the symbol C E. We know the current flowing for any load, but do not know the exact fraction of the applied E.M.F. usefully employed for external work. But if we divide the b.h.p. expressed in watts by the known currents, the value of the unknown volts is given. This quantity is divided by n to reduce it to volts per revolution. The efficiency is thus given us by dividing $\frac{\text{B.H.P. } 746}{n c} / \frac{E}{n}$, or efficiency $= \frac{\text{B.H.P. } 746}{c E}$. We now take a piece of squared paper, and set off the current as abscissæ, and for ordinates the volts per revolution (Fig. 3). Then we plot against the several currents the correspondin

values of $\frac{E}{n}$, $\frac{e}{n}$, $\frac{B.H.P.\ 746}{n\,c}$. This gives us three curves. Two of these rise from the origin 0; but the third, the curve of useful work, starts at that particular value of c, which is just sufficient to overcome the static resistance of the motor. It will be noted that these curves tend to diverge from parallelism as the load increases. They show on inspection two things of great importance in motor design. The height of the ordinates between $\frac{E}{n}$ and $\frac{e}{n}$ show the E.M.F. lost over the ohmic resistance of the machine when heated to its normal temperature. The distance between $\frac{e}{n}$ and the lowest curve $\frac{B.H.P.\ 746}{n\,c}$ shows the E.M.F. lost from all other causes—viz., material and magnetic friction, and by induction. These three curves give at a glance the value of the motor as a converter of energy, and they show not only where the losses occur, but they give the magnitudes. The several quantities are divided by n, simply because it is practically difficult to make a test with constant speed. Since n is proportional to $\frac{B.H.P.\ 746}{nc}$, and is the same for the three ordinates corresponding to each value of c, no error of importance is introduced.

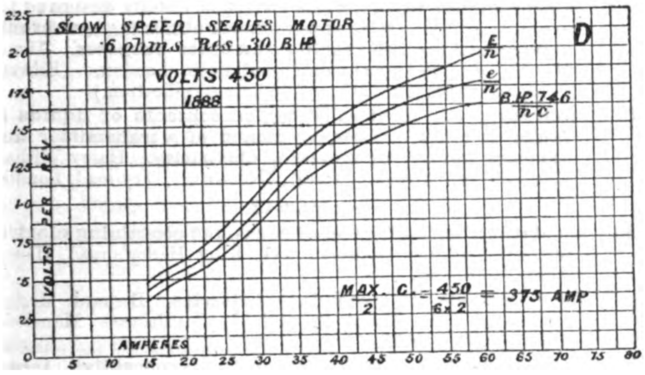

Fig. 3.

We now can see whether the losses, other than those due to the internal resistance, are excessive. The heat waste is a necessary evil, and can only be reduced within certain limits. The area between $\frac{e}{n}$ and the work curve can, however, be made very small. In a really well-designed motor this area should always be considerably less than that proportional to C^2 R.

If the losses due to friction and Foucault currents be larger than those caused by the copper resistance, the machine is badly designed. Our motor, however, will not only have a small value for C^2 R, but its other losses will not exceed $\frac{C^2 R}{2}$.

With these rough notes I close my paper. I may not have told you much that is new, but I hope to have made clear some of the more general difficulties, and to have put the design of motors on a simple engineering basis.

Discussion.

Mr. W. B. Esson: No one regrets more than I do the fact that Mr. Snell himself was not able to be present, but as I have talked over the paper with Mr. Snell, and he is fully aware of what I am going to say, he will probably be just as able to answer my remarks as if he were here. Taking the principle of reversibility, Mr. Snell finds that for a motor there is no critical current—that is, any current above that requires to overcome its friction will make it run. But for a dynamo a current lower than a certain value, called the critical current, is impossible. From this Mr. Snell seems to think that there is something radically wrong in the principle of reversibility, but I think this is a mistake. I made some experiments years ago to ascertain the effects of the reactions of the armature on the field, and concluded that in both dynamo and motor the effects were exactly similar. The case stands thus: Take a series machine and send a certain current through the field-magnets and armature. There is undoubtedly a delay in magnetisation, as pointed out by Ayrton and Perry some years ago, but I do not attach importance to this effect in continuous current machines. Although negligible in these, in alternate machines, however, the magnetic delay becomes enormously important. Well, neglecting this delay, let us send, in both motor and dynamo, the same current through the magnets and armature; it stands to reason that whichever way the armature turns the reaction must be exactly the same, provided that the back lead in the motor is equal to the forward lead in the dynamo. In a motor the only difference is that the armature runs round the other way, the magnetisation of the system and distribution of the field being the same in both cases. In the experiments mentioned, a dynamo was taken with a Gramme ring. This was run to produce several different currents. As a motor it was run at the same speed, and braked until the same currents flowed as were generated when it ran as a dynamo. With the current flowing in the same direction through the machine, the armature revolved, of course, in the opposite direction, the brushes having the tips rounded so that their ends did not turn up with the reversal. If V_1 and V_2 are the differences of potential at the terminals of the dynamo and motor, then I found in each case that—

$$V_1 + C\,R = V_2 - C\,R,$$

where C was the current and R the resistance of the machine. I concluded from this that the effect of self-induction might be neglected, and that the delay in the magnetisation of the armature core was also inappreciable.

Now we come to self-induction. In this direction I have been making several experiments lately, and find that in armature cores saturated to 18,000 C.G.S. the effect of self-induction may be entirely neglected. The experiments are made thus: The machine is separately excited, and run without any lead on open circuit, the E.M.F. and speed being noted, also the ampere-turns on the field. We now let a current flow through the machine and note the increase of excitement required to bring the E.M.F. to its previous value—that is to say, the difference of potential at the brushes is equal to its previous value *minus* the current into the resistance of the armature. There is no lead to the brushes, and therefore any weakening of the field is due to self-induction; and I find that at 18,000 C.G.S. the number of turns required to bring the potential when the current flows up to its former value is inappreciable, while at lower degrees of saturation a certain number of ampere-turns have to be added, which get larger as the saturation is reduced.

Regarding the effect of the armature lines on the field lines, I disagree entirely with Mr. Snell. It is quite true that Ayrton and Perry showed that the effects due to both might be added if the motor were worked with a forward lead, but if I recollect rightly, Ayrton and Perry stated that under usual conditions of work the brushes must have a negative lead. With this you must have a weakening of the field. You cannot have an increase—it is a physical impossibility. I might say that the very reason of a shunt motor governing so perfectly is due to this weakening effect on the field of the armature windings. As the current rises the field is weakened, and the effect is similar to that of a series coil wound on the magnets in the reverse direction to the shunt. For constant speed we require, therefore, no compound winding, but only a particular relation of field to armature. I have seen a motor in which the speed actually increased as the load was put on.

As to the ratio of field-magnet to armature cross-section, it is worthy of note that the cross-section of armature core can be varied very considerably without affecting to any considerable extent the number of lines of force through it. This arises from the fact that the ampere-turns required for the induction through the core is only a fraction of the total ampere-turns for the whole machine. In investigating this my firm constructed two armatures—one had a cross-section equal to ·6 that of the magnets; the other was ·8. The windings were similar, and so was the length; in fact, the only difference was that the hole in the centre of the armature was in one of them smaller. Although the increase in the cross-section was very considerable, the maximum increase in induction due to similar excitements was in the core of larger section only from 5 to 6 per cent. The gain is therefore so small for considerable increase in weight, that I think it is not worth while making two types.

For "useful" lines induced by the current in the armature core, Mr. Snell ought to substitute "useless," for, as I have already shown, the field is always weakened by them, not strengthened.

I may say that it is a very difficult thing to calculate the magnetic leakage before the machine is built, but it is very simple to measure the leakage afterwards, and from that it is tolerably easy to deduce the leakage in other machines, both of the same and modified types. One point is worthy of remark. Taking the single horseshoe magnet, suppose that in such a machine the ratio of the total lines of force induced in the magnet limbs to those passing through the armature core is 1·32. Now, imagine that you make a mistake in your calculation before the machine is made by assuming the ratio at 1·2, instead of 1·32. The error in the assumed leakage is 10 per cent., but the difference in the E.M.F. of the machine due to having made this error will only be about 2 per cent. The reason of this is that the number of ampere-turns required for the induction in the magnets themselves is fractional as compared with that required for the whole machine.

If the terminal difference of potential = V is the same in both dynamo and motor, their speeds will be in the ratio V + C R : V − C R, the dynamo, of course, being always the higher. I may mention that the efficiency of a motor is always greater than that of a dynamo at the same speed and current, the efficiencies standing in the ratio of $\frac{E}{E + C\,R}$: $\frac{E - C\,R}{E}$ where E is the E.M.F. generated in each case. Of course it makes no difference to the E.M.F. whether the armature is belt driven or current driven, provided the fields are in each case the same.

One of the chief reasons for the ampere-turns having to be increased over that shown by the calculation is, because in the calculation the demagnetising effect of the armature upon the field-magnets is neglected. This weakening effect is due to the lead of the brushes. In the Manchester machine, for instance, Dr. E. Hopkinson tells me that there are as many ampere-turns of series as of shunt wire, and the chief use of the series wire is to compensate the weakening effect produced by the current flowing through the armature.

Mr. Snell says, referring to the method I use, that I neglect leakage and self-induction. As a matter of fact, I neglect nothing, or rather I only neglect those things that are negligible. Self-induction is negligible, and the leakage I take always at one fixed ratio, an error in this producing, as I have shown, very small effect on the output of the machine.

In conclusion, I again express my regret at the absence of the author. Though my remarks have been of a somewhat critical character, it will be understood, I hope, that concerning all the points of which I have not spoken I have only to utter unqualified praise. They are only the points to which I in some degree take exception that I have called attention to.

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NEW COMPANIES REGISTERED.

Newcastle-on-Tyne Electric Supply Company, Limited.—Registered by Pattison, Wigg and Co., 11, Queen Victoria-street, E.C., with a capital of £50,000 in £5 shares. The objects for which the Company is established are: To act as undertakers for the supply of electricity for lighting and any other purpose within the city of Newcastle-on-Tyne and elsewhere within the counties of Northumberland and Durham. The first subscribers are:

	Shares.
T. G. Gibson, solicitor, 42, Mosley-street, Newcastle-on-Tyne	1
F. R. Goddard, St. Nicholas Chambers, Newcastle-on-Tyne	1
A. W. Heaviside, 7, Grafton-road, Whitley, Newcastle-on-Tyne	1
M. L. Lambert, Whitley Hall, near Newcastle-on-Tyne	1
R. Lord, 75, Pilgrim-street, Newcastle-on-Tyne	1
F. T. Merz, The Quarries, Newcastle-on-Tyne	1
J. Price, 6, Osborne-villas, Newcastle-on-Tyne	1
R. S. Watson, 141, Pilgrim-street, Newcastle-on-Tyne	1

The number of Directors shall not be more than nine nor less than three, and the above signatories shall act as first Directors. The qualification of a Director shall be the holding in his own right of at least £100 in the capital of the Company, and the remuneration of Directors shall be determined in general meeting.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the week ended January 11 amounted to £5,247.

Globe Telegraph and Trust Company.—A dividend of 1s. 3d. per share is announced by the Board of the Globe Telegraph and Trust Company for the past quarter.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting the fifth of the gross earnings payable to the London Platino-Brazilian Telegraph Company, were £4,248.

Pilsen, Joel, and General Electric Light Company.—Mr. G. Shead, F.C.A., of 9, Laurence Pountney-hill, E.C., and Mr. W. H. Trentham, of 4, Stanhope-street, N.W., have been appointed joint liquidators of the Pilsen, Joel, and General Electric Light Company, Limited.

Change of Address.—In consequence of Victoria-street, Westminster, having been renumbered, the address of Messrs. Allpress and Belshaw will in future be 49, Victoria-street, instead of 3 and 4, St. Margaret's Offices, as heretofore.

Direct United States Cable Company, Limited.—This Company recommend an interim dividend of 3s. 6d. per share, tax free, being at the rate of 3½ per cent. per annum, for the quarter ending December 31, ayable on and after the 26th inst.

Eastern Extension, Australasia, and China Telegraph Company.—This Company notify that the interest, due on February 1 proximo, on their six per cent. debentures will be paid on and after that date at the Consolidated Bank, 52, Threadneedle-street, E.C. Coupons must be left three clear days for examination.

PROVISIONAL PATENTS, 1889.

JANUARY 7.

266. **A bracket to support the ear piece of telephones and other similar instruments.** Thomas Boothby, 65 and 66, Chancery-lane, London.

276. **Portable dynamo-electric signalling apparatus for military and other purposes.** Charles Grant, 5, Kelvinside-gardens, Glasgow.

278. **Lightning conductor for telegraphic purposes.** George Wehr, 166, Fleet-street, London. (Complete specification.)

282. **Improvements in conduits for electric mains.** Fletcher Coates, 65, Friday-street, E.C.

292. **Improvements in electric alarm thermometers.** Percy Frere Luck, 45, Southampton-buildings, London, W.C. (Complete specification.)

JANUARY 8.

306. **A new method of ornamenting metal articles by electro deposit process on the articles, and filling in the ornaments with japan, varnish, paint or enamel.** William Highfield Jones, William Hall Jones, and Benjamin Highfield Jones, Ablow-street, Wolverhampton.

319. **Improved apparatus and connections for charging and discharging storage batteries.** William Prescott Kookogey, 321, High Holborn, London. (Complete specification.)

320. **Improved methods of preparing solution compounds for galvanic batteries.** William Prescott Kookogey, 321, High Holborn, London. (Complete specification.)

342. **Improvements in or relating to the regulation of dynamo-electric machines.** William Morris Mordey, 46, Lincoln's-inn-fields, London, W.C.

361. **Improved methods of and apparatus for welding, forging, and otherwise working metals by the aid of electricity.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States. (Complete specification.)

362. **Improved methods of and apparatus for welding, shaping, and otherwise working metals by the aid of electricity.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) (Complete specification.)

375. **Improvements in electric glow lamps.** Alexander Bernstein, 4, South-street, Finsbury, London. (Complete specification.)

377. **Improvements relating to the rivetting of metal plates and other objects by the aid of electricity.** Henry Harris Lake, 45, Southampton-buildings, London, W.C. (Elihu Thomson, United States.) (Complete specification.)

JANUARY 9.

385. **Improvements in electrical apparatus for preventing collisions between railway trains.** John Alexander Wilson and Frank Marshall Young, 41, Reform-street, Dundee.

435. **Improvements in dynamo-electric machines.** John Henry Holmes, Portland-road, Newcastle-on-Tyne, Northumberland.

JANUARY 10.

485. **Improvements in electric generators.** Henry Edward Newton, 6, Bream's-buildings, Chancery-lane, Middlesex. (Dionisio Piedrahita, France.)

JANUARY 11.

506. **Improvements in electrical switches, chiefly designed for use in connection with apparatus for obtaining synchronic movements for telegraphic and other purposes.** Henry Harris Lake, 45, Southampton-buildings, London. (Edward Fitzgerald Law, Turkey.) (Complete specification.)

549. **Indicating the level of water, or contents of liquids in tanks or other vessels, by means of a transmitter and recorder worked by means of electricity.** Harry William Charles Cox, 11, Galwey-street, Bath-street, City-road, London.

JANUARY 12.

586. **Insulating blocks for use with casings containing electric wires.** Frederick Bathurst, 111, King Henry's-road, Hampstead, Middlesex.

588. **Improvements in secondary batteries.** Bernard Mervyn Drake and John Marshall Gorham, 2, Prince's Mansions, Victoria-street, S.W.

590. **Improvements in liquid lamps for regenerative, incandescent, or ordinary lighting, heating, and general purposes.** John Henry Williams Stringfellow, 57, New Broad-street, City.

608. **Firing fog or other signals upon, or in connection with, a railway or tramway, either electrically or mechanically, the same being under control of authorised person.** Wm. Armstrong and Alfred Falconer Ball, 14, Lansdowne-terrace, Gosforth, Newcastle-on-Tyne.

613. **A combined holder for lamp and fuse with switch.** Walter Northcott Naylor and Walter James Naylor, 21, Finsbury-pavement, London.

614. **An improved form of electrical locking switch.** Walter Northcott Naylor and Walter James Naylor, 21, Finsbury-pavement.

SPECIFICATIONS PUBLISHED.

1887.

17,209. **Combined switch electric lamp support for conveyances.** Willing and Douglass. 8d.

1888.

1091. **Electrically-released counting mechanism.** Aird. 8d.
1254. **Electric lamps.** Spink and Gauzentes. 8d.
1798. **Telephonic transmitters.** Laurie. 8d.
1919. **Arc electric lamps.** Howes. 8d.
2073. **Electric alarm apparatus.** Iwanowski. 8d.
2251. **Electric circuit switches.** Graham. 8d.
2368. **Secondary batteries.** Bailey and Warner. 8d.
2438. **Incandescent electric lamps.** Langhans. 6d.
2450. **Electrical measuring instruments.** Hibbert. 8d.
8950. **Electrical traction.** Burdon. 6d.
10,604. **Secondary batteries.** Timmis. 6d.
11,082. **Transmitting and recording electrically autographic messages, &c.** Newton. (Gray.) 1s. 3d.
16,099. **Electrical switches.** Dorman and Smith. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	4¼
12 Feb.	2/0	— fully paid	5	5¼
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	19⅝
16 Mar.	5%	Maxim Weston	1	⅛
30 May	2½%	Oriental Telephone	11	½
26 April	4/0	Reuter's	8	7¼
......	...	Swan United	3½	2⅝
12 July	12/0	Telegraph Construction ...	12	41⅝
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	14

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NOTES.

Tramways in India.—Extensive tramways schemes are contemplated in Madras, and electricity will probably be used.

Windsor.—We understand that Messrs. Crompton and Co. have the order to supply a Crompton dynamo and a set of Crompton-Howell accumulators for Windsor Castle.

Society of Arts.—The date for the paper by Prof. Silvanus P. Thompson, at the Society of Arts, is fixed for Wednesday, March 6: subject, "Arc Lamps and their Mechanism."

Toulon.—The French Minister of the Marine has decided to fit the port of Toulon with electric light, to allow, in case of mobilisation, the troops and arms to be disembarked at night.

Seel Lamps.—The Seel Lamp Company are apparently making considerable strides on the Continent. They have lately sold their Belgian and Austrian patents, and works are being built in Brussels and Buda-Pesth.

Hyde Park Gate.—Consent has been given to the Kensington Court Electric Lighting Company to light the lamps at Hyde Park Gate, on condition that they hold the Vestry harmless against any loss or expense.

Underground Mains.—The St. James' Company have received permission to lay mains in Duke-street, St. James's, and other places, and the London Electric to lay mains through the Victoria Embankment Gardens, Charing Cross.

Electrical Road-Sweeper.—A project is afloat, we hear, to run an electric road-sweeper for London streets. This will be driven by accumulators, which also drive the revolving brush. No horses will be required, and one man will be enough to drive it.

Maxim Patent.—While financiers are trying to resuscitate the Maxim-Weston Company and sell patent rights, it would be as well to ask the question whether during the altercations the Maxim patents have not been allowed to lapse? If so, the company will not have much to sell.

Discussion on Electric Motors.—The adjourned discussion on Mr. Albion T. Snell's paper on "The Design of Electric Motors" will be continued at the Central Institution, South Kensington, on Wednesday next, at 7.45 p.m., when Prof. Ayrton is expected to make some remarks, and Mr. Snell to reply.

Birmingham Tramways.—It is definitely settled that the Bristol-road route of the Birmingham tramways, which was to have a cable system, is to be run by electricity, and application has been made to the Public Works Committee of the Birmingham Town Council for permission to use electricity as a motor along this route.

Ganz and Company.—The new alternating motor by Ganz and Co., of Buda-Pesth, entirely surpassing the Tesla motor by requiring only one circuit, is expected to do great things in the development of the motor industry. The same enterprising Austrian firm have just brought out a new and solid type of dynamo, built on excellent mechanical and electrical principles, which they called the Delta dynamo.

Gottenburg.—It may be remembered that Gottenburg is to be electrically lighted by a local company. The permanent plant will commence with sufficient power to provide current for 2,000 lamps, but before Christmas a trial run with a temporary 500 light plant was successfully made, and since then the accumulators have been installed and a trial made. The plant is by Messrs. Crompton and Co., and is giving complete satisfaction.

Chelsea.—The Vestry, on the recommendation of the Electric Lighting Committee, dissent from the granting of a proposed provisional order in the case of the London Electric Supply Corporation, Limited. Memorialists are also informed that the jurisdiction of the Vestry in the matter of overhead wires is limited in extent, difficult of application, and doubtful in its effects, and that the Vestry are not prepared at present to initiate litigation against the owners of the overhead wires.

Shoreditch.—The Shoreditch Vestry are recommended by their Parliamentary Committee—chiefly for the reason that overhead wires would be a source of great danger, and they were of opinion that no legislative sanction should be given to any scheme which included such a system—that the Board of Trade be memorialised not to consent to the present application by the London Electric Supply Corporation for a provisional order to lay down mains for the public and private lighting of the parish.

City Lighting.—At the meeting of the Commissioners of Sewers on Tuesday, which is the last of the present Commission, the Streets Committee brought up a report recommending that tenders for the electric lighting of the City, which was divided into three parts for the purpose, should be at once invited. The matter is left for the new Commission to carry out. It was also resolved that the court should formally oppose the various applications for electric lighting provisional orders so as to obtain a *locus standi* before Parliament.

Proposed Electric Tramway.—The tramway world is beginning to awaken to the advantages of electric traction for their work, which we have so persistently dinned into their ears, and various schemes are afloat for the introduction at once of the new system. One of these is for Morecambe, and, as will be seen from the advertisement, the Morecambe Tramways Company now invite tenders for the equipment and working of their line by electricity. This is the first invitation for a public tender for an electric tramway in this country.

Paris Exhibition.—Some of the large Davey-Paxman engines for the Paris Exhibition are now on the ground. Behind these engines and within the English machinery section will be a large installation by Crompton and Co., who will provide the electric lighting in the whole of the English and American and a large part of the French section of the Machinery Gallery. The French Government intend to supply the steam-power gratis to those exhibitors who require it, and to do this they will themselves purchase it of the exhibitors who produce it.

Newington.—At the Newington Vestry, on Wednesday, upon the recommendation of the Works and Sanitary Committee, it was resolved that the application of the House-to-House Electric Light Supply Company, Limited, for the consent of the Vestry to enable the company to apply to the Board of Trade for a license be not entertained; but they recommended that no objection be offered to the draft provisional order lodged by the London Electric Supply Corporation, or any action taken to watch the progress of the order through Parliament.

West Brompton Station.—The central station of the House-to-House Electric Light Company, at West

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Brompton, was formerly opened for inspection yesterday. We have already given particulars of this station and a sketch plan of the arrangements on December 14th last year, and we shall give further details and illustrations of this most interesting station, which has its own special design of machinery, dynamos, meters, regulators, and switches from beginning to end. The station will be ready to light up in about three weeks, the first instalment being for about 12,000 lamps.

Berlin.—The central station at the Markgrafenstrasse, Berlin, has been increased to the extent of 1,200 h.p., and is connected with the station at the Mauerstrasse, which supplies the arc lamps to Unter den Linden, both stations having now a total of 3,900 h.p., capable of supplying current for equal to 40,000 incandescent lamps. Two further stations will be opened in the spring in the Spandauerstrasse and the Dorotheenstrasse, with 2,000 h.p. each, and that at the Mauerstrasse will also be increased by a similar amount, so that within three years the Berlin Electricitätswerke will have installed a total of about 14,000 h.p., equal to 150,000 incandescent lamps, or its current equivalent.

Burglar Alarms.—The recent homicidal burglary at Muswell Hill has aroused great indignation and even terror amongst suburban residents. The time would no doubt be ripe for a large disposal of electric burglar alarms, and supply electricians might reap a small harvest from this cause. Amateurs are becoming busy with their electric arrangements, and the *Standard* has a letter from "Paterfamilias," describing a simple alarm which he has fitted consisting of an old box-lid fitted with two brass screws as contacts, and hinged at or laid under a fur mat at the windows for the burglar to tread upon, which rings a loud bell in the hall. An advertisement in the society papers should bring a good crop of orders just now.

Overhead Wires.—At the Paddington Vestry on Tuesday, Mr. Mills moved: "That it be referred to the surveyor to prepare and furnish the Vestry with a return showing (*a*) a list of the streets and thoroughfares in the parish that are crossed by overhead wires; (*b*) the number of separate crossings of wires in each street; (*c*) the names and addresses of the persons or companies owning such wires; (*d*) the cases in which the erection of the wires has been sanctioned by the Vestry (for the purpose of determining whether in any, and, if in any, in what instances, rights of user have been acquired); (*e*) the dates respectively when the wires were erected." He contended that the wires were a great eyesore, and were here likely to be a source of considerable danger to the public. The motion was carried unanimously.

New York Subways.—The Board of Electrical Control of New York reports to Governor Hill that 240,155 lineal feet have been excavated for laying subways, and that 2,287,880ft. of single duct for telephone and telegraph service have been constructed in this city. The total capacity for wires is about 34,665 miles for telephone and telegraph, and 600 miles for electric light and power wires. They say that 4,453 miles of electrical conductors have been placed in the subways. The report complains of the escaping steam from the pipes of the Steam Heating Company. It also says that from 30 to 50 per cent. of existing poles and wires are "dead," and exist in violation of the rules of the Board, which have not been enforced by the proper authorities. The report says nothing of the degree of perfection of the subways as built.

Elwell-Parker.—The new and extensive works of Elwell-Parker, Limited, which we alluded to some time ago, are to be erected at Bushbury, just outside Wolverhampton, and adjacent to the main line of the London and North-Western Railway. The growth of the business of this company has been phenomenal, and reminds one of the rise of business firms in the first days of railway engineering: we recollect calling at the works when two or three sheds and 50 men were the extent of the premises. The present works are to cover some 12 acres, and will be occupied in manufacturing every kind of heavy electrical plant. Continuous and alternating lighting plants and depositing dynamos are now largely made, but the greatest development will probably be in tramway and motor work generally, for which the company are, we believe, specially laying themselves out. Besides the contract for the Birmingham tramways, they hold some valuable contracts for lighting, among which is one from Melbourne to the value of £20,000.

Swansea.—A scheme is proposed by the harbour trustees at Swansea, which is likely to encourage the thorough adoption of electric light in that town. The Corporation of Swansea, as already announced, are taking steps to obtain a provisional order. The preliminary steps were taken some three months ago, but it is not likely that the required sanction can be obtained for at least another three months, especially as the gas company may be expected to very strenuously oppose the innovation. This being so, it is encouraging to learn that the lighting by arc lamps at the East Dock has been so successful that the harbour trustees are intending to adopt the complete lighting of the whole dock estate by electricity, and it is suggested that the trustees will also agree to light Wind-street and other main streets adjacent to the docks with their surplus power. By this means, when the provisional order is under consideration, the town will have the advantage of experience of the light which has already proved itself satisfactory to the harbour trustees.

Edison Consolidation.—The announcement is made that the various Edison electrical manufacturing companies are to be consolidated into one Edison General Electric Company. The capital of the new company is close on £2,500,000. The incorporators are E. H. Johnson, the president of the Edison Electric Light Company; Samuel Insull, the manager of the Edison Machine Works; F. R. Upton, the vice-president of the Edison Lamp Company; C. Batchelor, of the Edison Laboratory, and A. O. Tate, Mr. Edison's secretary. The company thus formed takes over the Edison Machine Works, the Edison Lamp Company, and the big factory of Bergmann and Co., where details of the Edison system have been made; and it is understood that new factory facilities are to be provided at West Orange, N.J. Mr. Henry Villard and the well-known Deutsche Bank of Berlin are understood to be interested financially. It is said that the technical affiliations will include some of the leading firms in Europe—that of Siemens and Halske being one named.

Lamp-posts for Bath.—A Taunton firm, Messrs. C Allen and Son, Tone Engineering Works, has secured the contract for lamp-posts for the electric lights at Bath. The tenders are as follows: For about 340 iron electric light posts, 30ft. above ground, with roots varying in depth 3ft., 4ft., 5ft., and 6ft. respectively, with independent flanges projecting 2ft., to be fixed with wrought

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wedges, delivered free in Bath, on Midland and Great Western rail, or water, for Mr. H. G. Massingham, Bath ; Allen and Son, Taunton, £6. 10s. (accepted); G. Smith and Co., Glasgow, £7. 7s. 6d.; Buller, Jobson and Co., Dudley, £7. 10s.; M. and W. Graybrook, Dudley, £8 ; Easton and Waldegrave, Taunton, £8. 2s. 6d.; Jukes, Coulson, Stokes, and Co., London, £8. 2s. 6d.; Statter and Co., West Drayton, £12. 7s. The firms tendering supplied their own designs. Messrs. Allen's posts, while being the cheapest, have ornamental brackets to support the lamps, and are fitted with an ingenious arrangement by which the lamps can be easily lowered, doing away with the necessity for carrying ladders for fixing and cleaning the lamps.

The Electric Motor in Mining.—A very interesting application of the electric motor to mining operations is that of a 5 h.p. Sprague motor at the works on the Big Bend River in California, where efforts were made last year to get at the river bottom and to extract the gold there supposed to have been deposited through the long centuries by the auriferous waters on their way downward from the mountains. The motor is at the end of an eight mile circuit, and the efficiency obtained at the point in question is 65 per cent. The work done was that of pumping out a shoal of water 600ft. square and 10ft. deep on the average. The whole shoal was unwatered in four days of 24 hours each, by two of the Sprague 5 h.p. motors. The pumps were in charge of a miner 60 years old, who two days before the installation was made did not know what a motor was. In his hands everything went well, however, and the service was perfect. In fact, no energy but electric could have been used in the place, the river running at the foot of precipitous mountains through deep gorges and narrow clefts in the rock. The potential used on the circuit was 600 volts.

Electrolytic Method of Liquefying Gases.—In the *Journal* of the Chemical Society an abstract is given of a paper by Mr. H. N. Warren : Strong hydrochloric acid is introduced into a combustion tube, bent at right angles, so as to cover two small platinum plates fused into the closed end of the tube; a plug of asbestos, saturated with concentrated sulphuric acid, is placed at the bend, the open and shorter arm is then fused up and immersed in a freezing mixture. On the passage of a current through the plates, gas is evolved and liquefies at the other end, but on removing the tube from the freezing mixture and discontinuing the current, the liquefied hydrogen chloride is reabsorbed by the water. The experiment may then be repeated. Other compound gases behave in a similar manner. When acidified water is decomposed in this apparatus, and a platinum plate covered with platinum-black has been fused in the short end, explosions occur there at intervals, and small quantities of water form, containing hydrogen peroxide, and having an ozonised odour. With chromic acid and water, the blue oxide of chromium is obtained. The method has also been applied to the liquefaction of oxygen and hydrogen, and the latter is said to have been "decidedly liquefied."

Overhead Telephone Rights.—The Corporation of Dorchester have attempted to take a new position with regard to the running of telephone wires overhead. Claiming the absolute ownership of the streets and roads, they have objected to the Western Counties and South Wales Telephone Company carrying their wires over such streets unless under their license, and with an undertaking to remove them after due notice. The Court of Appeal have long decided that wires may be carried over public roads at sufficient height without consent of the Highway Boards or local authorities. The Telephone Company cannot see their way how to admit the authority of the Corporation except, of course, over such property as is owned by the Corporation in the usual way, and have suggested that they either accept a license from the Corporation in respect of any property over which the Corporation are entitled to make such a condition, leaving its limits to be defined in event of any dispute (which would probably never arise), or to settle the question at once in any expeditious and inexpensive way by appeal to opinion of the court or a judge. Failing these arrangements, the Telephone Company, not having many subscribers in Dorchester, would be inclined to withdraw from the town and omit it from their system.

Gas Mains as Electrical Conduits.—The problem of conveying telephone and electric lighting wires underground in large cities has received a partial solution in New York, where for the last few years a telephone conductor has been run inside a gas main, between the gas works of the Consolidated Gas Company at 99th and 111th streets. The conductor enters the gaspipe by a stuffing-box, made gas-tight by plaster of paris. The wire is carried by glass insulators fixed in the roof of the pipe. The length of the circuit is over half a mile, and it has been in continual use. Owing to the success of this experiment, a series of new mains have recently been supplied with telephone cables, serving for the use of the gas company. The experiment tends to show that the mains of a gas company might even be employed for running the wires of an electric lighting company undergroυrd. It has been objected that a short-circuit in electric light circuits must cause explosions and tear up the whole city, but it is evident that a mixture of air and gas would be necessary for an explosion, for a gas jet on an open pipe does not produce the same effect. A deposit of carbon would be the only result in this case, which would increase while the leak continued. At any rate, there may be usefulness in the adoption of telephone wires for the gas companies themselves.

Electromotive Force of Selenium.—In the *Journal* of the Chemical Society the following abstract is given of a paper by S. Kalischer (*Ann. Phys. Chem.* [2], 35, 397—399). The author points out that the method described in von Uljanin's paper (Abstr., 1888, 883) of preparing selenium sensitive to the production of E.M.F. by the action of light had been described by him two years ago (Abstr., 1887, 693). He states that in the paper by Fritts, quoted by von Uljanin as well as by himself, there is no question of an E.M.F. caused by the exposure of selenium to light, as he had already pointed out. Righi, in a recent paper, states that he has obtained a current from a selenium cell in the dark, and suggests that the reason that other observers have not noticed this is that they have attributed the whole E.M.F. to the action of light. Kalischer states that he had tried to obtain an effect of this kind, but without result, and he says that it does not appear from Righi's description that daylight was totally excluded in his experiments. He points out, moreover, that the method of observation of the effect of light would preclude any interference from such an effect if it existed, and that the E.M.F.'s observed are therefore entirely due to light, and not the resultants of these and of effects of the kind which Righi states that he has obtained.

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Electrical Exhibition at Birmingham.—We gave particulars in our issue of January 11 of a proposed Electrical and Industrial Exhibition, to be held in Bingley Hall, Birmingham, during the months of August, September, and October this year. The preliminary organisation is now complete, offices have been taken, and the regulations issued. The list of patrons comprises a large number of well-known names, including Lord Salisbury, Earl Compton, Mr. John Bright, Mr. Chamberlain, and many public men of Birmingham and the district, together with a formidable list of scientific men, headed by Sir William Thomson, with Mr. W. H. Preece, F.R.S., Profs. Hughes, Adams, Fleming, Perry, Forbes, and others. The exhibition will be, to a very large extent, electrical, as, indeed, all industrial work will rapidly tend to become, and will present a splendid opportunity of bringing forward the immense possibilities of the commercial application of the present developments of electrical industry in the centre of manufacturing England. A general prospectus of the proposed exhibits was given in the number mentioned above, and the main conditions are as follows: The forms of application for space must be filled up and delivered before 15th April. A charge for space of from 1s. 6d. to 2s. 6d. per square foot will be made, a remittance of 25 per cent. of the amount to accompany the form of application. Power will be supplied where necessary at the cost of the exhibitor. No exhibits will be received before 15th July, and must be delivered before the 22nd July. Applications will receive attention in priority of reception, and as the space for exhibitors in each section is limited an early application is advisable. Applicants for space from foreign countries and the colonies must appoint representatives in England to act on their behalf. Applications for space should be addressed to T. C. Sharp, manager, County-chambers, Corporation-street, Birmingham; telegraphic address, "Exhibit," Birmingham.

Electrolytic Inner Cells.—The *Electrical World* describes a new form of battery made by Messrs. Roberts and Brevoort, of New York, in which the difficulty experienced with porous cells with the diffusion of acids on the one hand if too porous, and high internal resistance on the other if but slightly porous, is overcome. In what may be an important improvement in batteries, these inventors have made the partition separating the two liquids in a battery of a material which should practically be non-porous, but with electrolytic properties, so that whether the battery be on an open circuit or closed, the liquid, as such, on one side of the partition would not interfere or intermingle with the liquid on the other side of the partition, or only to a very limited extent; but when the circuit is closed, and the battery is called upon to give a current of electricity, chemical action could take place through the partition. This property in a partition has been secured by the use of a number of materials. Among those first tried were gelatinous or jelly-like materials, such as boiled starch, which was confined between walls of cloth, so as to make a suitable diaphragm, and other vegetable and animal substances of a similar nature have been used. In the most recent form the inventors employ mineral substances of a gelatinous nature, and among others they tried the gelatinous silicate of soda, with which they impregnate the ordinary porous cup. The action of this diaphragm or partition the inventors explain as follows: The diaphragm or partition is a non-porous substantially-solid homogeneous wall, whose particles, while sufficiently solid and compact to maintain their compositions, and so prevent, for practical purposes, any transmission of fluid through them, are yet themselves able to act as electrolytes, and suffer such decompositions and re-combinations as are essential to the electrolytic transmissions of electric force. In other words, they have in the partition combined in the one substance the solid properties of the earthenware and the electrolytic properties of the liquid, or, as they say, they have made the electrolytes solid, and the partition electrolytic. The results obtained by the use of this non-porous partition are reported to be highly satisfactory, so that very nearly the entire theoretical amount of energy contained in the zinc is obtained as current in the external circuit, due to the absence of local action, even when the cell remains idle for long periods of time.

Central Station for Manchester.—A proposal to establish a station for Manchester, somewhere within half a mile of the Manchester Royal Infirmary, for a maximum of 10,000 lights, was brought forward at a special meeting of shareholders of the Manchester Edison-Swan Company on Tuesday last. Such a station would cost, including the laying of mains down the chief streets in the centre of Manchester, a sum of £40,000, with £8,000 a year for maintenance. If the whole of the lights were let at an average of 25s. per light, this would produce £12,500 per annum, or something above 10 per cent. on the original cost of the station. It was proposed that the charge per light should be graduated according to the number used. The estimate stated was regarded by the directors as a thoroughly reasonable one. Various proposals, fair even to the point of seeming to be generous, had been made unofficially to the Manchester Corporation, one of the proposals being that the company should not make more than 10 per cent. out of this new portion of their business, and that at the termination of any specified period the Corporation should have the privilege of buying up the undertaking for the benefit of the ratepayers. What was earned over 10 per cent. the consumers would receive the benefit of. The following resolutions were moved: "That this extraordinary general meeting of shareholders of the Manchester Edison-Swan Company, Limited, approves of the proposed scheme for the establishment of a central electric lighting station in Manchester, and authorises the directors to raise the required capital by making a call or calls, not exceeding in the aggregate £2 per share, as and when they may be required. The meeting expresses its earnest hope that the Corporation of Manchester may be induced to give the necessary facilities to enable the directors to carry the scheme into effect." "That a copy of the foregoing resolution be sent to the Mayor of Manchester and to every member of the Corporation." It was objected that the scheme was too philanthropic; that the shareholders would have to find the money, and in event of success would be limited to 10 per cent., the consumers getting the further benefit, whereas if loss were sustained the shareholders alone would suffer; and that the scheme was too speculative for the company to undertake. After further discussion, the motions were agreed to on the understanding that a canvass should be made to see how many people were willing to use the electric light and the Corporation approached on the subject, but that no money should be spent till the shareholders had had another opportunity of expressing their opinion about the proposal.

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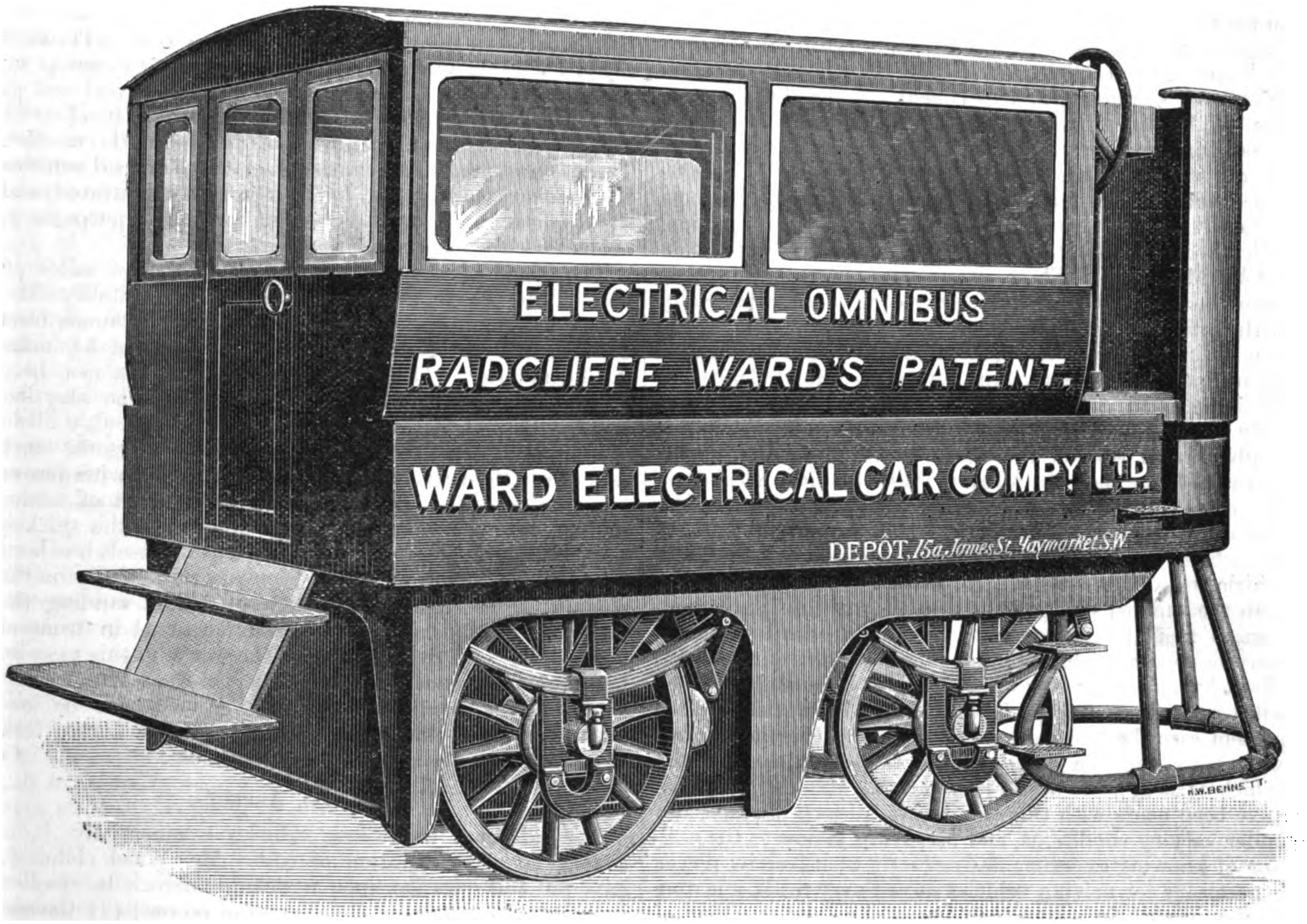
RADCLIFFE WARD'S ELECTRIC OMNIBUS.

Some little time ago we alluded to the running in the early hours of the morning of an electric omnibus—the first of its kind—along the roads of London. We are able this week to give a full description and illustration of this new departure in electric traction, at the same time calling attention to the capabilities of such a mode of traction for various classes of goods transport along the ordinary roads.

Until the end of last year there has been, in reality, no legal regulation dealing with carriages propelled along the streets by electricity. The only power which dealt with vehicles other than those drawn by horses on the streets was that given to the Board of Trade, under the Highways and Locomotives Act, which was passed to regulate the running of traction engines and steam rollers. It was in this that occurs what is known as the "red flag clause"—the Board of Trade regulations with reference to steam haulage specifying that the speed was not licenses can be obtained through any postal money order office under the Inland Revenue Department, and specify "carriages with four or more wheels and fitted to be drawn by two or more horses or mules, or by mechanical power." The definition is as follows:

> "The term 'carriage' means and includes any carriage (except a hackney carriage), drawn by a horse or mule, or horses or mules, or drawn or propelled upon a road or tramway, or elsewhere than upon a railway, by steam or electricity or any other mechanical power, but does not include a waggon, cart, or other such vehicle which is constructed and adapted for use and is used solely for the conveyance of any goods or burden in the course of trade or husbandry, and whereon the christian name and surname and place of abode or place of business of the person or the name or style and principal or only place of business of the company or firm keeping the same shall be visibly and legibly painted in letters of not less than one inch in length."

The first license for an electric carriage for ordinary roads under the new regulations has been taken out by the



to exceed four miles an hour, and that a man with a red flag must precede the engine by a distance of 400 yards. It has never been fully acknowledged by electrical engineers, or indeed insisted upon by the Board of Trade, that this act includes the regulation of carriages propelled by electricity, and we believe, as a matter of fact, there was no authority capable of objecting to the use of electric vehicles. Now, however, we are glad to say, this uncertainty is overcome. A careful consideration of the Act and of the Board of Trade regulations has shown that steam traction engines, or road locomotives—fuel-consuming engines—were alone in view in these regulations, every reference pointing to this special subject. The propulsion of ordinary carriages and waggons by electricity had never been contemplated, nor even conceived of, at the time these regulations were adopted, and the conditions are entirely inapplicable to the new demands. At the last session of Parliament, therefore, when a Bill for the Readjustment of the Excise Duties was brought forward, in the clauses where carriage licenses are referred to, special mention is made of carriages propelled by electricity, and at the present time two-guinea licenses can be obtained for these, as for any other form of four-wheeled carriage. The Ward Electrical Car Company, Limited, 15A, James-street, Haymarket, S.W., for the electric omnibus now described. The legal difficulty is therefore evidently practically at an end. For carrying passengers, such an omnibus would have also to be registered under the police regulations in the same way as other carriages plying for hire.

It is not to be supposed that upon merely taking out such a license any person who wishes to run upon the ordinary roads any electrically propelled vehicle can do so without further regulation. At the present moment there is no authority regulating such method of traction, but it is clearly to the interest of the public and all concerned that proper regulation under competent and independent authority should be carried out, after the needs and possibilities have been ascertained, and to stipulate, for instance, that all such carriages should be fitted with proper brakes to stop within a certain distance, and to carry such and such necessary appliances, etc. The Board of Trade have this matter under consideration, and a short special Act, brought in as a Government Bill, giving the Board of Trade the requisite power, would be all that is necessary.

With these preliminary remarks upon the licensing of electric carriages, we will pass to the history and descrip-

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tion of the present undertaking. Mr. Radcliffe Ward has been connected with the introduction of electric traction from the very commencement. While engineer to the British Electric Light Company (who were working the Gramme patents) he assisted in what was probably the first experiment in electric power transmission, which took place early in 1879, for Captain Blanch Brain at the Trafalgar Collieries, Forest of Dean, Gloucestershire. In this case, the motor (a Gramme dynamo reversed) was stationary, and was used to haul coal trucks, and in so far this was not electric traction as now known, but the ability of the motor to work for these purposes was amply demonstrated. The result of these experiments was the establishment of an electric pumping station, which is still at work on the Forest of Dean. In the year 1881 the introduction of the Faure accumulator rendered possible the application of stored electrical energy to the purposes of tramway work, and the first electric car made was run by Mr. Radcliffe Ward on the Leytonstone line in 1882. M. Philippart, who had the introduction of the Faure battery on his hands, conceived the idea of applying it at once to tramcars, and arrangements were made with Mr. George Richardson, then chairman of the North Metropolitan Tramways Company, to experiment on the Leytonstone line. M. Philippart had this, the first electric car, constructed in Belgium and sent over to England, and the working of the car was in the hands of Mr. Radcliffe Ward. Numerous experiments were made, and some fundamental patents in variable-speed gearing, and details of the construction, which became evident on application in practice, were taken out by Mr. Ward. These experiments were only abandoned because of the unsatisfactory condition commercially of the only storage battery on the market. Some little time after, he started the construction of a car to run over the ordinary roads, but again, owing to the difficulty of obtaining good accumulators, this was dropped. In the early summer of 1887 he built an electric cab, which was exhibited and run on the roads at Brighton, and it was about this time that Mr. Magnus Volk also built his electric dog cart, which was described in the illustrated papers, and there excited the attention of the Sultan of Turkey, for whom Mr. Volk has recently constructed a similar vehicle.

In the summer of 1888 the first electrical omnibus commenced to make runs over the London streets in the early morning hours. This omnibus is not of the type that will be used for running, for which purpose a model omnibus will be designed, and special cells ordered to fit this. In the present case the best storage cells obtainable for the purpose were used, and the omnibus built to carry these, and the vehicle is as appears in the illustration. Many experiments have been made with this omnibus on all sorts of roads, and under varying conditions, and Mr. Ward is now in the position of knowing experimentally exactly what tractive power is necessary for driving vehicles on ordinary roads, a matter of the utmost importance in the design and working of electric vehicles of this kind, and which has until now been more or less problematical.

From time to time we have had a note about the working of the electric omnibus, and have watched with interest its progress, knowing that such work is the inception of a vast development of the practical application of electricity to ordinary civilised life. It is therefore fitting that a representative of the *Electrical Engineer* should have been the first to officially take a ride upon the electrical omnibus. Starting one morning last week, at 7 a.m., from a mews in Cromwell-road, South Kensington, we had an opportunity of judging the capabilities of the new car. It has the appearance of something between an ordinary closed bus without top seats, and a parcels delivery van, of course without horses, and is capable of seating twelve persons comfortably. The driver sits or stands in front, with a switch and resistance frame, and handle with worm-gearing to steer with, and a powerful foot-brake. It is powerfully built to sustain the weight of accumulators, which slide in trays under the seats.

The cells are the new type E.P.S. traction cells, and were the first set of this type made by the Electrical Power Storage Company. The motors, of which there are two, are Gramme machines, built by Crompton and Co., Limited, which have proved to be thoroughly reliable and efficient. They are connected with steel chain-gearing by Hans Renold, of Manchester, which are also thoroughly satisfactory. Mr. Ward has tried all the available methods—friction, chain, belts, and toothed wheels: they all have advantages for special conditions, but he finds the gearing he has adopted the best for these circumstances. The double-speed gearing alluded to has not been fitted to the first omnibus, but will be fitted for the cars to be used for ordinary work. The framework of the omnibus was constructed at the works of the Metropolitan Railway Carriage and Wagon Company, Limited, Saltley; the wheels are of special make to Mr. Ward's designs.

The car, which had been running the day before, started off easily and was run along Cromwell-road and Knightsbridge, turning into Hyde Park at the Albert Gate. The morning was bright and clear, and the ride was very pleasant. Not many people were about at this early hour, but the early tradesmen and workmen were of course moderately astonished at seeing the novelty. What it was, however, there could be no mistake about, for the lettering on the omnibus is large enough for all to read. Through Hyde Park was an easy and pleasant run; turning up by Hyde Park Corner the bus went on up the hill and out at the gate and along Upper Brook-street, across Bond-street into Regent-street, and thence into James-street, Haymarket. There is no doubt that the question of electrical road vehicles has been well tackled and its possibility demonstrated, and the application to ordinary work for many purposes is evidently only a matter of time.

The speed of the car is about six to seven miles an hour, about the same speed as that of an ordinary bus; a run has been made without stopping, for instance, from Notting Hill to Golden-square—a distance of 3½ miles in 30 minutes. The running of the car has not been attempted amongst the ordinary traffic in the daytime at present, but there would be no great difficulty about this, especially for heavy and slow-moving waggons—such as railway delivery vans, dustcarts, etc.—and with proper means of thorough control these would admit of taking their place in a crowded string of vehicles in the thickest London streets. The question of the slip of wheels has been freely tested, the cars having been run successfully on the slippiest days. This is mostly a matter of sanding the road, and a sand-tube can be easily arranged in front of the wheels. At the same time there are in this case no horses to slip down. Another point is the saving in dust from the droppings; the wear and tear will also be less, for this is greatly due to the pounding of the horses' feet, like eight sledge-hammers on the pavement.

Commercial Aspects.

The adoption of electric vehicles commercially is, of course, largely a question of cost. Mr. Ward claims to have put this question upon a definite basis. It resolves itself into three points: (1) the cost of power; (2) the cost of depreciation of the cells and car; (3) how much power it is necessary to expend to run certain weights upon the ordinary roads.

Definite estimates have been obtained from established manufacturers for the establishment of a power station for supply of current, with absolute guarantee of certain output at specified rates, by which it is undertaken that electricity can be produced at about 3d. per unit. There are several companies who will guarantee a certain depreciation of their cells, and will undertake contracts to keep them in repair at reasonable rates. The power necessary to drive such vehicles has now been ascertained, and the cost per mile for various vehicles calculated, and Mr. Radcliffe Ward claims that the result, all under guarantee from responsible manufacturers, shows a very considerable saving over the cost of horse vans. There is little doubt, if this means of traction proves successful in practical work, that the employment in towns and in connection with railway collecting and travelling generally the introduction of large numbers of electric vehicles would give an immense impetus to the electric industry.

For electric light stations it opens up a new source of profit. The dividends obtainable from electric generating stations will undergo a total change when there is the possi-

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bility of selling large quantities of electricity during non-lighting hours for the purpose of operating vehicles, and private firms possessing dynamos might find a new source of profit.

With regard to the weight of the car, this is largely a question of rapidity of discharge of cells. The present car is rather heavy, but even here the weight per square inch surface of wheel upon the road is less than that of an ordinary bus, both being fully loaded. Ordinary buses take about two hours for a return journey. A battery of sufficient power which would be able to be discharged in this time would be very much lighter than those in present use, and there are indications that both the pasted and plain lead cells are approaching the necessary conditions of rapidity of discharge. The cells now used are extremely good and efficient, and there is talk of an improved plain lead cell which will give an extremely rapid discharge, and such a cell is the desideratum for this class of work.

The object of the Ward Electrical Car Company, Limited, will be probably not so much to sell as to contract to do work with electric cars. Neither do they intend, unless they see some special inducement to the contrary, to go themselves into the manufacture of electrical appliances. They propose rather to avail themselves of the existing electrical manufacturers. They are able at the present moment to make contracts for supply and maintenance of several different types of accumulators which will give satisfactory commercial results for street vehicle purposes, and, of course, many types of motors made by different firms are at their disposal.

The Ward Electrical Car Company are at the present moment discussing the question of electrically-propelled vehicles on a large scale with several of the most important railway companies, as however great the economy may be for omnibuses, it must be very much greater for vehicles such as goods and parcels vans, which stand about such a large proportion of the time they are out. The same remark applies to cabs, but in these the speed must be greater, and it must be seen how far the conditions are suitable for this work. The company also are going into the question of operating dustcarts and such vehicles. This, alone, is an enormous business. They are also considering the question of establishing lines of omnibuses in combination with the existing proprietors of omnibuses, or otherwise.

The first contract taken by Mr. Radcliffe Ward and handed over to the Ward Company is for an electric goods cart for a London tradesman. It is now building, and the trial trip will take place shortly.

It will readily be understood that in a new branch of work such as this many special devices and appliances have proved to be necessary for the commercial carrying out of the work, and the Ward Company consider that they have many patents which will prove of commercial importance in the affair. At the same time, when the practicability of electric traffic has been demonstrated, the application of motors to ordinary vehicles may become general, and will tend to the benefit of the whole electric industry.

ELECTROLYSIS OF COPPER SALTS.

BY ALEXANDER WATT.

(Concluded from page 59.)

43. *Ammonio-chloride of Copper.*—To prepare a bath from this salt, a moderately strong solution of salammoniac was added to a solution of protochloride of copper, the ammonium salt being added in moderate excess, and the resulting solution afterwards diluted with water. Electrolysed with the current from a single Daniell, a deposit of copper slowly formed on the edges only of a steel plate used as the cathode, but after a minute or two a partial film gradually spread toward the centre of the plate, but no deposit took place on the upper part of the cathode, while the back of the plate was only slightly coated at the side edges, no metal appearing on the lower edge of the plate. Two cells were next tried, when the deposit formed more quickly, but, as before, the film started from the edges of the plate, gradually converging towards the centre, but entirely avoiding the upper surface. When the plate was somewhat briskly agitated in the bath for about half a minute, the deposit gradually became dissolved off, leaving only a slight but very bright film of copper at the edges of the plate. This experiment was repeated with a freshly prepared steel plate, when, as before, the copper deposited while the plate was stationary in the solution, but gradually disappeared when it was kept briskly in motion. It was indeed very interesting to notice how effectually, though somewhat slowly, the deposited metal became dissolved from the plate, until at last only a narrow band, about one-eighth of an inch in width, was left, the upper outline of which formed a deep downward curve. With the current from three cells a very bright deposit formed on the edges of the plate, and gradually extended all over it, while the plate remained stationary; but when briskly moved about, the film again disappeared as before. A plate of steel received no deposit in this solution by simple immersion, but a clean strip of zinc, when immersed in the liquid, quickly received a bright coating of copper, which did not, however, alloy itself with the zinc, as is very generally the case, but formed a distinct film, which, being non-adherent, was readily removed from the plate by scouring with moist sand. On examining the anode, it was found to be coated with a lumpy green deposit of oxide.

44. *Ammonio-chloride of Copper with Chloride of Ammonium.*—A moderate quantity of the ammonium salt was afterwards added to the foregoing solution, when with the same current deposition took place more slowly, while the deposited copper was of a paler colour, and, as before, only adherent at the edges, where the film was brightest. In other respects, the addition of salammoniac did not appear to present any advantage.

45. *Iodide of Copper in Cyanide of Potassium.*—To prepare this solution, recently precipated and moist suboxide of copper was dissolved in a strong solution of cyanide of potassium, a moderate excess of the latter being afterwards added. The solution was then moderately diluted, and electrolysed with the current from three Daniells. With an anode surface about equal to that of the negative plate, copper deposited rather slowly, and was of a pale colour. The metal, however, adhered very firmly to the steel surface. A small quantity of the strong cyanide solution was next added, and a fresh steel plate immersed, when deposition took place more promptly, and the character of the film greatly improved, being not only better in colour, but also very bright, while, as before, the metal was perfectly adherent.

46. *Oxide of Copper in Acetate of Ammonia.*—Moist hydrated oxide of copper was digested in a strong solution of acetate of ammonia, in which it became freely dissolved, forming a dark blue liquid. The solution thus obtained was then moderately diluted with water, and electrolysed with the current from one cell, when a bright film of copper quickly formed on a steel plate; when the cathode was briskly agitated in the bath, the film gradually dissolved off, as in the case of the ammonio-chloride of copper solution. When the plate was allowed to rest undisturbed in the bath, a film of good colour was obtained, but the metal did not adhere well to the steel. The solution was afterwards diluted with water in small portions at a time, and it was found that the deposits from the weakened solution improved progressively so far as tenacity is concerned. When, however, the dilution had extended to about four times the original bulk of the liquid, the subsequent deposits became wavy and of very bad colour. A second cell was then connected, and a freshly-prepared plate immersed, which at once received a bright film of copper of good colour. After remaining in the bath about ten minutes, however, the primary layer of the metal became coated with a dark powder of a purple-brown colour, which was readily removed by the finger. On removing this loose, non-reguline deposit by scouring the plate with sand, the film first deposited became exposed, and was found to be firmly adherent. It was subsequently found that the deposits from the diluted bath did not become redissolved, as in the cases mentioned, when the cathode was briskly agitated in the liquid during the electrolysis; indeed, when a clean plate was im-

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mersed in the solution, and kept constantly in motion, it became well coated with a bright, reguline and perfectly adherent film of copper. On examining the anode, it was noticed that small green lumps of oxide had formed upon some parts of the plate. These, however, redissolved in the liquid after a time, and the anode became perfectly clean. An excess of acetate of ammonia was next introduced, and a fresh steel plate immersed, when deposition took place so rapidly that it was found necessary to reduce the current to that of one cell, when more satisfactory results were obtained, the deposits being exceeding good in all respects, but more particularly when the cathode was kept gently in motion.

47. *Oxide of Copper in Bisulphate of Potassa.*—A solution was formed by digesting moist hydrated oxide of copper in a strong solution of the bisulphate, in which it was readily soluble. The resulting solution, which was of a pale blue colour, was afterwards considerably diluted with water and electrolysed with the current from a single cell and very small anode surface. The deposits first obtained with this bath were of a darkish colour, therefore the liquid was repeatedly diluted until the film assumed the characteristic colour of the metal, which was not effected until the solution had become exceedingly weak. It was hoped that a bath of this composition might be useful for coating iron, but it was found that the deposited metal, even in the weakest solutions, did not adhere perfectly to steel or iron.

48. *Suboxide of Copper in Citric Acid.*—To prepare a bath of this composition, recently prepared and moist suboxide of copper was digested in a strong and warm solution of citric acid, in which it dissolved freely. The solution was then moderately diluted with water. With the current from two cells, a very bright film of copper gradually formed on a steel cathode, which adhered very firmly to the plate, and resisted both hard scouring and burnishing.

49. *Suboxide of Copper in Hyposulphite of Soda.*—A strong solution of the hyposulphite was first prepared, to which was added, a little at a time, moist suboxide of copper, which soon became dissolved, forming a pale greenish-blue solution. This was afterwards diluted with about an equal volume of cold water. With the current from one cell, a very bright film of copper was obtained, which was found to adhere well to the steel surface of the cathode. A plate of zinc also received a very firm coating of copper in this bath.

50. *Chromate of Copper in Caustic Potash, etc.*—Recently precipitated and moist chromate of copper was digested in a strong solution of caustic potash, which freely dissolved it, and the liquid was afterwards diluted with about four volumes of water. No deposit of metal could be obtained from this solution with the current from three Daniells in series. A solution of the chromate in cyanide of potassium was next tried, but with no better success. Chromate of copper was afterwards dissolved in ammonia, but the solution failed to yield a deposit of copper with the current named.

51. *Oxalate of Copper.*—This salt being very sparingly soluble in water, only a very weak solution could be obtained. With the current from two cells, however, a pretty quick deposit was obtained upon a steel plate, which adhered very firmly. When a plate was left undisturbed in the bath for a few minutes, the loose purple-brown deposit before noticed again formed, proving that the current was too strong. A single cell was, therefore next used, and a new plate immersed, when deposition proceeded more slowly, and the film retained its reguline character. It was found necessary, however, in order to prevent the formation of the powdery deposit, to reduce the anode surface considerably—indeed, to the extent of about one-fourth that of the negative electrode. Under these conditions the metal deposited in a perfectly reguline state, and firmly adhered to the steel surface of the receiving plate.

52. *Oxalate of Copper in Ammonia.*—A quantity of oxalate of copper was first prepared, and the precipitate well washed and allowed to settle. The last washing water being now poured off, strong liquid ammonia was gradually added, the mixture being stirred after each addition until the oxalate was dissolved. The resulting solution, which was of a dark blue colour, was next diluted with about four times its bulk of water. With the current from a single Daniell no deposit of copper could be obtained; with two cells, however, a very bright and firmly-adhering film was received upon a steel plate. The anode surface immersed was rather less than that of the negative electrode.

53. *Oxalate of Potassa and Copper.*—A solution was formed by digesting moist carbonate of copper in a strong solution of binoxalate of potassa, and the solution then set aside to crystallise. The crystals were next dissolved in water, and tried with the current from one, two, and three cells in succession, but no deposit of copper took place until the third cell was connected, when a steel plate slowly received a film of copper, which firmly adhered to its surface. A copious green deposit of oxide formed on the anode, which dropped from the plate in the form of a powder, and collected at the bottom of the vessel.

54. *Subchloride of Copper in Chloride of Ammonium.*—Protochloride of copper was heated in a crucible to bright redness, and a portion of the resulting subchloride was then powdered and gradually added to a strong solution of salammoniac, in which it slowly dissolved. The solution thus obtained was afterwards diluted with water and electrolysed with one cell, a very small anode surface being immersed. A film of copper at once formed upon a steel cathode; after a few minutes' immersion, however, the film on the front of the plate was found to present a very beautiful iridescent appearance, in which dark green and blood-red patches were most prominent, while the back of the plate was uniformly coated with a deep blood-red film of remarkable beauty. This coloured film was readily removed by gentle rubbing with the finger, by which the film first deposited became exposed. The liquid was next considerably diluted with water, and the anode surface further reduced, when a newly-prepared steel plate promptly received a bright film of reguline copper; shortly after, however, the deposit again indicated a disposition to iridescence, to prevent which the cathode was kept gently in motion while in the bath, which effectually prevented the formation of non-reguline metal and a good deposit of copper was thus obtained, which was found to adhere to the steel surface with perfect tenacity. Attempts were subsequently made, by further dilutions of the solution, to obtain good reguline deposits upon the cathode without the aid of motion, but these were only partially succesful.

55. *Tartrate of Copper.*—A small quantity of this salt was prepared, but as it is very sparingly soluble in water, only a very weak bath could be obtained. This was first tried with the current from two cells, which, however, proved to be insufficient, so a third cell was added, and a rather large anode surface immersed, under which conditions a film of copper at once began to form upon a steel plate, the metal being very adherent. An addition of tartaric acid was next made, when the operation progressed somewhat more vigorously, a very good film being obtained in about a quarter of an hour.

56. *Phosphate of Copper in Tartaric Acid.*—A quantity of phosphate of copper was first prepared by adding a solution of phosphate of soda to one of sulphate of copper, the resulting precipitate being afterwards allowed to settle, the supernatant liquor then poured off, and the precipitate next washed in several waters. After removing the last washing water, a strong solution of tartaric acid was gradually added to a portion of the precipitated phosphate until it became dissolved, which was promptly effected by the tartaric acid solution. A moderate proportion of cold water was next added, and the solution was ready for use. With the current from two cells a very prompt and bright film of copper was received upon a steel plate, which very firmly adhered to it, and fully resisted the action of hard scouring with moist silver sand.

57. *Copper Phosphate in Citric Acid.*—A further portion of the precipitated phosphate of copper was next dissolved in a strong solution of citric acid, in which it was very freely soluble, forming a pale-blue liquid. This solution, after being moderately diluted, was electrolysed with the current

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from two cells, when a bright deposit of copper rapidly formed upon a steel plate, the coating being exceedingly firm and of very good colour. An attempt was also made to obtain a solution of the phosphate in acetic acid, but this was found to have little or no solvent action on the copper salt.

58. *Ammoniuret of Copper in Bisulphate of Potassa.*—A strong solution of the bisulphate was first made, to which was gradually added recently precipitated and moist ammoniuret of copper, which readily became dissolved by the potash salt, forming a pale blue solution, which was afterwards diluted with about four times its bulk of water. With the current from a single cell a deposit of copper of a disagreeable dark colour quickly formed upon a steel plate, and it was found necessary to further dilute the liquid considerably to reduce the speed of the deposit. As it was found that the deposited metal under these conditions was non-adherent, the solution was abandoned.

59. *Copper Sulphate with Tartaric Acid.*—Having frequently noticed that the addition of vegetable acids to solutions of metallic salts formed with the mineral acids in some cases improved the character of the deposit, I determined to add to a moderately dilute solution of copper sulphate varying proportions of tartaric acid, in the hope that the mixture would yield adherent deposits of copper, which it is well known cannot be obtained from a solution of sulphate of copper *per se.* To prepare a bath, a rather weak solution of copper sulphate was first made, and to about 10 ounces of this solution was added 60 grains of tartaric acid, which was allowed to dissolve in the liquid. With the current from a single cell, and small anode surface, a steel plate promptly became coated with copper, which was found to be very adherent, and well resisted hard scouring with moist silver sand. After being rinsed and dried, the deposit was tested with a steel burnisher, the pressure of which it withstood without stripping in the least degree. It seems not improbable that a solution of this character, which might be modified by still larger but not excessive additions of tartaric acid, could be found useful for coating iron. It is generally understood that a nearly insoluble tartrate of copper becomes deposited from weak solutions of the sulphate to which tartaric acid has been added, but I may say that, with the exception of a very trifling deposit of the tartrate salt, I have not so far noticed any appreciable separation of the tartrate from the dilute solution referred to.

In pursuing the course of experiments which I have had the pleasure to record in these papers, I also electrolysed solutions of numerous other copper salts, but as the results obtained were in many instances of a negative character, it was not considered advisable to make any special reference to them. It is to be hoped, however, that from some of the solutions to which I have called attention may be selected several which the practical operator may deem worthy of further trial at his hands. In reference to such solutions I have thought it advisable to direct special attention, as some of the results which I obtained from them somewhat suggest the probability that a substitute for the cyanide of copper bath may be found amongst them. Again, I have endeavoured to point out which of the solutions tried is most favourable for yielding bright deposits of copper, as such solutions may be useful for coating certain small articles, or parts of metal work, for which a bright deposit of copper may be desirable. I may repeat here a statement made in the opening paper of this series—namely, that all the solutions named were worked at the ordinary temperature—that is, not artificially heated; but I may further add that the temperature of the laboratory in which the experiments were conducted (it being during the winter season) never exceeded 46deg. F. Those who have been accustomed to deposit copper from hot cyanide solutions, with all their pernicious effects on the health of the operator, will readily appreciate the advantages which would be derived from a harmless electrolyte that could be practically worked at the ordinary temperature of the atmosphere even in winter. If such a solution can be found amongst those which I have suggested, it will be a source of much satisfaction.

CORRESPONDENCE.

CORRECTION.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I note in your copy of my notes on "Design of Motors" one error, which I shall be obliged if you will correct.

In the expression for torque, equation (γ), C_a = *the total current flowing in the armature*, and not "the current flowing in one coil," as given in your copy.—Yours, etc.,

ALBION T. SNELL,

Electric Works, 19, Malden-crescent, Prince of Wales'-road, London, N.W., Jan. 22, 1889.

CENTRAL STATION LIGHTNING ARRESTERS.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I should be greatly obliged to any of your numerous readers who would inform me what is the best simple form of central station lightning arrester to protect the dynamos; I have not heard of any that has been at all extensively used. Also what is used for "bearers" for overhead cables, and what are the "hangers" made of.—Yours, etc. A. I. E. E.

ELECTROLYSIS OF CHLORIDE OF SODIUM.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I observe that a paragraph quoted from the *Moniteur Industriel* has recently been running through the columns of the American journals to the effect that Mr. N. N. Beketov, a Russian chemist, has "made an interesting communication to the Technical Society of St. Petersburg on the subject of a *new system* of decomposition of chloride of sodium, which may have important results in the manufacture of soda ash and caustic soda." It is stated that Mr. Beketov made his first experiments, in 1885, according to the Hefler process, but the results not being satisfactory, "he has now treated electrolytically the salt in a state of fusion, and at this temperature, which with sea salt is 500deg. C., its conductivity is sufficient to produce electrolytic decomposition." With your permission, I will endeavour to prove that the so-called "new system" is nothing more than the reproduction of a process invented and patented by my brother, Mr. Charles Watt (chemist to the Australian Government), in the year 1851. In order that there should be no question as to the true origin of this method of treating chloride of sodium, I quote the following passages from my brother's patent, dated September 25, 1851: "The second part of my invention consists in a mode of preparing or obtaining the metals of the alkalies or alkaline earths by the united action of electricity and heat." The specification then goes on to describe the vessel in which the operation is conducted, "which is made of iron or other suitable material capable of bearing a full red heat. . . . The vessel is filled with dry saline matter, so that when it is in a state of fusion it shall reach the dotted line (indicated in the drawings which accompany the specification); the partition (also shown) keeps the eliminated substances from reacting upon each other, and also excludes the air from the compartment in which the metal is eliminated, the access of which would cause the metals to be oxidised. The vessel is placed in a furnace where it can be subjected to the action of a full red heat, and when the saline matter is in a state of fusion, contact is made between the decomposing vessel and the apparatus supplying the electric current. . . The fused salt is maintained at that temperature which will ensure the instantaneous volatilisation of the metal. . . The salts which I usually employ are the chlorides, iodides, or bromides of the metals of the alkalies or alkaline earths."

It will be obvious, from the few passages quoted, that Mr. Beketov's "new system" is really an old one after all; and I may say that this is not the first time that I have had to call attention to the reproduction of my brother's invention, as I think it but right that the public should know that there is no novelty in the decomposition of fused chloride of sodium by electricity.—Yours, etc.,

Balham, Jan. 18, 1889. ALEXANDER WATT.

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NOTICE.

During the course of the past year we issued steel engraved portraits of Mr. E. Graves, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. Wollaston, M.D., F.R.S., *and* Sir Humphry Davy, F.R.S. *The portraits of* Prof. D. E. Hughes, F.R.S., *and of* Dr. J. Hopkinson, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

THE INSTITUTION OF ELECTRICAL ENGINEERS.

Close upon the assumption of its new title, under which the late Society of Telegraph Engineers and Electricians will now be known, the council of this Institution have sent forth an edict which is sure to create considerable interest and possibly some unfriendly comments in more than one quarter. We refer to their decision of banishing the Press from the general meetings of the Institution. In future we and our contemporaries are not to report these proceedings. Such, at least, is the request conveyed by a letter from the secretary, which is before us. Says Mr. Webb: "I am instructed to inform you that the council have come to the conclusion that it is not desirable that the proceedings of the Institution's general meetings should be reported in the Press, and they request therefore that you will abstain from so reporting them." We cannot say that we were absolutely unprepared to find that the Institution desired to exercise some control over the way their meetings are reported—for one of our contemporaries had some weeks ago divulged proceedings at the council table which should have been kept private—but we were not prepared to be thus summarily deprived of a privilege which we have hitherto enjoyed. The dissemination of information in the quickest and most effective way is one of the principal duties of a journal, whether technical or otherwise, and accurate reports of the proceedings of a learned society are from this point of view most valuable to the readers of technical journals. Being thus suddenly debarred from giving our readers early information of what is brought before the Institution, we naturally ask ourselves, What have we done to incur the displeasure of the council and merit this sudden dismissal from our post? Well, we have done nothing detrimental to the interests of the Institution, and for this very reason we are inclined to the belief that this new rule is not conceived in a spirit hostile to the Press, which belief receives confirmation by the fact that the secretary promises to send proofs of the papers to be read before the Institution for publication in the technical Press. It is certainly annoying to find ourselves suddenly hemmed in by this new rule, but, after all, the council of the Institution of Electrical Engineers have a right to their opinions, and if they pass rules which are inconvenient to the technical Press it is only fair to remember that they were elected to look after the interests of the Institution and not after those of the electrical journals and their readers. As one of these journals, we dislike the new rule, but we admit that, from the Institution's point of view, it is a step in the right direction.

We are not in the confidence of the council, and even were it otherwise it would not be seemly for us to publish what by its very origin must be private information. We can therefore not say

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PROF. W. E. AYRTON, F.R.S.

Although perfectly familiar with the difficulties and dangers of attempting to produce good portraits in papers, the work upon which has necessarily to be carried out under high pressure, we have determined to attempt to record not only the names but also the features of those who sit around Sir William Thomson, and under him guide the fortunes of the Institution of Electrical Engineers. The portraits now given will be supplemented from time to time by steel engraved portraits, several of which, as our readers know, we have had in preparation for months past. Prof. Ayrton is a type of those Englishmen whose energy has swayed the destiny of nations. For years past his name, together with that of his colleague, Prof. Perry, has been found in the front rank of those whose life-long aim is the progress of physical science. It is not our intention to attempt to give lengthy biographical notices. The men we have to deal with in this series are men well known to most of our readers—men moving among us, men to whom we look for guidance, and men to whom we look for information. Prof. Ayrton, we believe, first saw the light in Yorkshire. He was educated partly at University College Schools, and, subsequently to his gaining first place in the entrance examination for the Indian Government Telegraph Service, under Sir W. Thomson at Glasgow. After varied and excellent service in this department, he was in 1873 elected Professor of Natural Philosophy at the Imperial College of Engineering, Japan, where he remained till 1879. Soon after his return to England he was elected Professor of Physics by the City and Guilds Institute, and since then his career is familiar to us all. The Institution of Electrical Engineers owes much to the energy and the organising powers of Prof. Ayrton, for when he returned from Japan the society could by no torture of language be stated to have been in a very prosperous condition. Certainly he woke some of us up from the sleepiness into which we had fallen, and for this, if for nothing more, our best thanks are due. He has written and edited books, and contributed papers in a continuous stream to the learned societies, and at the same time has invented or improved various pieces of electrical apparatus. As a speaker he is exceedingly fluent, and possesses a complete mastery of his subject.

PROF. W. E. AYRTON, F.R.S.

Prof. Ayrton has been consistently in the front in all questions relating to electric light and power. His lecture at the Sheffield meeting of the British Association was a revelation to many, but perhaps his best work in this particular direction was his popular lecture at the last meeting of the British Association at Bath. This lecture was twice delivered to an overflowing audience. Perhaps the practical man connects his name more closely with simple and portable measuring instruments than with anything else, and no doubt such instruments have been largely manufactured and used from his designs. We are never very certain about mentioning Professor Ayrton's name alone, for his twin brother in scientific work has for so many years been so closely connected with him in all that he has done that the result should possibly always be stated as due to—no, not a torque, but a couple. Between them they have contributed a vast amount of information relating to motors, to dynamos, to telpherage, besides the work previously referred to on measu ing instruments. He is an excellent French scholar, and contributes articles to the French technical papers. As a professor he is getting around him some of the best talent of the rising generation, and we think this is the greatest possible proof of his fitness for such a position. Were we to add among his other idiosyncrasies that of a humorist, the impeachment would not be misplaced. But we think everyone will allow that the greatest compliment we can pay Prof. Ayrton is to say that he is Prof. Ayrton, and none other.

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what may have been the reasons which caused the council to suddenly adopt an attitude which is apparently hostile to the Press. But if we do not know the reason, we can make a pretty shrewd guess, or, better still, think the matter out for ourselves, adopting for the purpose Charles Reade's excellent precept of "put yourself in his place." Now suppose our place were not the editorial chair in Salisbury-court, but a seat at the council table of the Institution of Electrical Engineers, and we should then view the matter in a very different light. We would at once recognise that the Institution has by its new title assumed an outward and visible sign of the rank to which it aspires. We would be anxious to see its status raised as much as possible, and cast about for means to accomplish this object, and try to remove difficulties which might stand in the way. Now there can be no doubt that indiscriminate reporting is not calculated to enhance the status of the society forming the object of these reports. The principle of allowing the sayings and doings of a society to be carried before the world by literary free lances totally beyond the control of the members of the society is hardly calculated to benefit the latter. On the contrary, it is likely to do harm. The perfect freedom to report, comment, and criticise may eventually engender a spirit of familiarity, and lead to the Press dictating to the council in what way it should manage the affairs of the society. We do not say that this has already taken place in the case of the Institution of Electrical Engineers, and we are quite sure that we ourselves have never been guilty of such an offence, but as we have put ourselves for the sake of argument into the place of a councilman, we must consider the eventuality that such a thing might happen. There is, however, another consideration of still greater importance. Electrical engineering in this country is now in full development. Scarcely a week passes without some large new electric light company being formed, each having its own particular system and stock-in-trade of patents, concessions, etc. Now these companies require financial support from the public, and to get it they are all anxious to show that their particular mode of going to work is the best. For this purpose the Institution of Electrical Engineers offers an excellent opportunity, provided always that the proceedings are widely and quickly published. If Mr. So-and-So wishes to get a gratuitous advertisement for his system or his company, he has only to wait his opportunity when a suitable paper is read and join in the discussion. If he be a fluent speaker, and understands how to advertise himself skilfully without overstepping the limits of scientific discussion, he will be able to say a great deal which, from a business point of view, will be very useful to him when it appears next week in a full report in the technical journals. His remarks may contribute nothing at all to the science or practice of the subject under consideration, yet he may continue to give the reader the impression that he knows the subject better than any other electrician, or that his company has the best system in the world for lighting, power transmission, or whatever the subject may be. The fact that he has been permitted to air his views at so influential a learned society as the Institution of Electrical Engineers gives him some sort of credentials when he wants financial support from the public, and the temptation to make the Institution merely a place for self-advertisement is therefore very strong. Suppress the reporting and this temptation is at once taken away. Mr. So-and-So will then know that his remarks can only reach those who are perfectly able to appraise them at their true value, and he will give way to other speakers who have something useful to communicate. A rule similar to that now introduced by the council of the Institution of Electrical Engineers has been in force for many years at the Institution of Civil Engineers, and with most beneficial results. The proceedings of this learned society are, beyond question, a pattern to all, not only in the practical value of the information conveyed, but also in orderly dignity. The meetings are always crowded, because members cannot get the information except by personal attendance, and although the advertising element is not totally absent, as it never can be where the majority of members are business men, it is not thrust prominently into notice. By following the lead of the Civil Engineers, the Institution of Electrical Engineers is not likely to have made a mistake in introducing this new rule regarding the abolition of indiscriminate reporting. Although as journalists we may dislike the rule, as members of the Institution we cannot but approve it.

THE "HOUSE-TO-HOUSE" COMPANY.

To the Editor of The Electrical Engineer.

Sir,—I should not have troubled to reply to the letter of the secretary of the above company had he confined himself to facts. But he tries to mislead your readers by what I can only describe as a perversion of the truth. He asserts that the Bath Corporation have "somewhat reluctantly" concluded a contract with me, etc. The exact contrary is the case. At my suggestion, the Corporation decided to entertain lighting all the principal thoroughfares with arc lamps, and grant facilities for the supply of private lighting. This question has been under their consideration for more than 12 months. Advertisements for tenders appeared for two successive weeks in each of the three technical journals. Each contractor was required to tender for overhead and underground mains. Ten tenders were received, of which the one sent in by myself (on behalf of a local supply company) being the lowest, both for overhead and underground mains, was accepted. All those who had taken the trouble to make themselves acquainted with the peculiar difficulties in the way of running underground mains in this city recommended overhead wires, and the majority of the Corporation being of the same opinion, that method was adopted. At the meeting when the final vote was taken, of a council numbering 54 members, only one gentleman voted against the contract being signed.

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Considering that gas for the public lamps is charged only 1s. 11d. per thousand in Bath, the well-wishers of electric lighting throughout the country were surprised at the almost unanimous vote of the council. In common with others the House-to-House Company had the opportunity of tendering, but it does not appear to have answered their purpose to enter the field of fair and open competition. The following report of what took place when the application of the House-to-House Company was read, shows the feeling of the members of the Bath Council: Mr. Cox said that was an application for another company to go in and do the work which another company was engaged to do, and before they knew how it was to be done. They were in a transition state at present, and no interference should be allowed.—The Chairman: How can we, after arranging with one company, entertain proposals from another?—Mr. Sturges: We would not be allowed.—The Chairman: Well, I don't think so.—Mr. Mitchell then moved, and Mr. Sturges seconded, that the matter be referred to the Electric Light Committee. This was unanimously agreed to.

The opponents of electric lighting in Bath are delighted at the "dog in the manger" policy of the "House to House" Company, but the friends of electricity naturally regret it. The insinuation of the secretary of the "House to-House," to the effect that they possess the most perfect installation yet constructed, and are the only people capable of undertaking central station work, may be correct, or it may be their own opinion only. In any case I prefer to employ firms of standing and repute, who have already given me unqualified satisfaction, but whose names I purposely withhold, as I do not wish to make your correspondence columns a means of advertising any particular firm or company. The secretary of the "House-to-House," in true imitation of the "Maxim-Weston" Company in its worst days, refer to my calling in terms neither true nor complimentary. I am usually described as a boot and shoe manufacturer and leather merchant, but this gentleman (?) very politely designates me a "boot and shoe maker."

During the past four years my association with the electric lighting industry has been of a most agreeable character, and all professional electrical engineers with whom I have come into contact have been honourable business men and gentlemen, but the promoters of the "House-to-House" Company appear to be exceptions to this rule.—Yours, etc. H. G. MASSINGHAM.

1888.

(Concluded from page 51.)

CROMPTON AND CO. have been engaged during the year principally in carrying out central station work. The large station at Vienna has been completed, and is working in a thoroughly satisfactory manner, and they believe that the results obtained are, as regards economy and efficiency, far higher than has been obtained elsewhere. In England they have manufactured the plant for the extensions of the Kensington central station, as well as plant for other central stations not under their own control, and for abroad complete sets of central station plant have been supplied for Gothenburg, in Sweden, for Le Mans, in France, and for several small towns in our Australian colonies. The large dynamo machine for electric smelting for the Cowles Aluminium Company was set to work during the year, and after some difficulties, arising from the unexpectedly heavy currents which the machine had sometimes to carry, is now working perfectly, running continuously and giving its full output of 5,000 amperes and 65 volts. They have also made several large machines for electro-depositing work. As regards isolated sets of plant of considerable size, they have been for some time past carrying out the electric lighting plant for the new docks at Port Barry, and for the extensions at Cardiff. They made some very heavy sets of plant for ship lighting, notably for the P. and O. steamers and for the new White Star steamers. In addition to the usual routine work of supplying all kinds of electric lighting plant to their various agents, they have introduced a novelty in the shape of electric cranes, which have been a great success; one of these was recently described by us, so here needs no further mention. Generally speaking, the tendency of the year has been towards the manufacture of very large and heavy dynamo machines. Frequently as many as half-a-dozen machines of the 100-unit size would be seen in the shops at one time.

JOHN DAVIS AND SON, of All Saints Works, Derby, have been very busy in the electric lighting branch of their business during the latter part of 1888. In addition to plants ranging from 200 to 60 lights, they have done a good deal of extension work, including a large increase of arc light plant at Messrs. Bass, Ratcliff, and Gretton's brewery, Burton-on-Trent. In one colliery plant, in South Wales, the underground main roads are lighted throughout, the furthest lamp being considerably over half a mile from the dynamo.

Sunbeam lamps have been extensively used, and it may be of interest to note that in a dust-tight reflector fitting (a speciality which this firm manufacture) a 300-c.p. lamp will enable ordinary print to be read at a distance of 70 yards. They are now putting down the nucleus of a small central station, consisting of dynamo power (including spares) of 14 units, and an accumulator of seven units. In the power department they have in prospect a telpher line about one mile long, and an underground hauling plant to transmit about 120 h.p.

SIEMENS BROS. AND CO.—During the past year the various works carried out have been mostly of the ordinary kind, and there is little of an exceptionally important character to record. In the electric light department the company have either completely fitted or supplied dynamos, etc., to about 60 ships, about half of which belong to H.M. Government and the remainder to the principal passenger lines of steamers, besides fitting up several pleasure yachts for English and foreign owners. In the same department they have completed an installation at the Viceregal Lodge at Simla, and at three palaces and some bungalows of native princes in India. In England they have carried out several installations in mansions and private houses, and are now engaged on a contract for supplying electricity to the town of Bradford, in Yorkshire. In connection with this contract, Messrs. Siemens are using for the underground wires their new lead-covered cables provided with special high insulation and outer protective covering of sheet iron, which are found to be highly suitable for such purposes. In the cable department, among numerous orders of various descriptions, they have supplied and laid a cable across the Gulf of Mexico, on which work the ss. "Faraday" is at present engaged.

J. G. STATTER AND CO.—The year has been devoted, speaking generally, in standardising various sizes of dynamos, electromotors, and steam-engines, and arranging combined engines and dynamos. They have also brought out a new type of arc lamp—designed more especially to burn with moderate currents of from 6 to 10 amperes —a new cell tester, and a new magnetic cut-out. The firm's constant current dynamo, brought out in the autumn of 1887, has been improved and standardised, and is employed in several places, where it is doing good work. It is believed that this is the only constant-current dynamo—not employing a regulator in the field-magnets—commercially made and sold in England.

In transmission of power there is a large field of usefulness for constant-current machines and motors. A generator has lately been supplied for a constant current of 50 amperes at a variable E.M.F., according to the requirements of the motors it has to drive—the maximum is 350 volts, at a speed of 560 revolutions per minute. This generator is for series tramway work. They have also in hand a 20-h.p. generator and motor, the working conditions of which are somewhat peculiar. The generator will be driven by a turbine, which may vary its speed some 8 per cent., while the motor, which is a mile away, is required to keep its speed constant within 3 per cent. By means of their constant current principle, such conditions are satisfactorily met.

Dynamo work has been fairly brisk, especially during the latter part of the year. Machines of all size and voltages

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have been supplied. In arc-light machines (constant current), machines of 1,200 volts, 800 volts, 400 volts, and smaller. In incandescent lighting, three 28-unit machines have recently been supplied—a pair for the Lyric Theatre and one for factory work. Twelve, nine, and six-unit machines have also been in fair demand.

In combined engines and dynamos several sets for ship lighting and mill lighting have been supplied, and the arrangement adopted of driving with short-link belt with setting in pulley (Jockey pulley) gives great satisfaction, and diagrams show that very little power is wasted. Both engine and dynamo are on one bedplate. The speed of the engine is in all cases moderate, being about 250 revolutions per minute in medium sizes, while that of the dynamo for the same set is 900 revolutions per minute. Both engine and dynamo are, therefore, under favourable conditions for economical working, and for minimum wear and tear. In electric light engines the work for the year, though not extensive, has been satisfactory. The type of engine made is what the Americans term an "automatic engine"—that is to say, the governor acts directly on the cut-off and is placed on the crankshaft. The engines are specially stiffly built for high steam pressures, and to enable them to withstand the wear and tear of long continuous runs the crankpin is lubricated by a centrifugal lubricator, and the whole of the lubricating arrangements are suitably arranged for the particular work. Although the central stations in England are few and far between, no less than two of them derive their power from "automatic engines," and negotiations are going on by this firm with the contractor for supplying a third station. Several projectors have been supplied to foreign Governments, and the patent diverging gear for varying the field, illuminated by the projector, meets with great approval. Three projectors supplied had automatic lamps—two for 100 amperes, one for 50 amperes. A special projector with our latest improvements is in hand for a foreign Government. The firm's measuring instruments are gradually extending in favour as their accuracy becomes more generally known. The business done in 1888 in these is about double that of any previous year.

WOODHOUSE AND RAWSON and the subsidiary companies have kept themselves well to the front during the past year. The principal company, Woodhouse and Rawson, Limited, has been very busy with a large number of installations for important people and firms, such as Messrs. W. H. Smith and Son, Peek, Frean, and Co., Lord Brassey, Messrs. Crosse and Blackwell, the Palace of Mysore in India, the Institute of Medical Electricity, etc. They also have done a good deal in working out new processes, such as Messrs. Elmore's copper depositing process, of which we hope to give particulars later on. As is known, they lay themselves out specially for new applications of electricity such as this.

The new price list brought out by the Woodhouse and Rawson Electric Supply Company of Great Britain, Limited, shows that this company also has been well to the front. The bringing out of a price list of this description does not only amount to a compilation of a certain number of pages of matter, but it means that the company must necessarily be doing a large business in these goods, as otherwise one cannot get a knowledge of the business which this catalogue shows the company to be in possession of, and low prices cannot be obtained unless one is able to place orders in large quantities. We hear that in the last six months the sale of electrical goods and goods connected therewith has increased nearly threefold.

Woodhouse and Rawson Electric Manufacturing Company, Limited, is chiefly known for its manufacture of incandescent lamps and instruments—such as switches, etc. The company have introduced during the past year a large number of new instruments—Wirt's rheostat, Pyke and Barnett's coils, Vernon Harcourt's standard instruments—such as pentane burner and holophotometer—Baker's wire-testing apparatus, and other specialties of a like nature. We hear that, on account of the very satisfactory way in which their new lamps with unflashed filaments are turning out, the company are about to reduce their standard efficiency from 3·5 watts per c.p. to 3 watts per c.p.

ELECTRICITY: LIGHT AND POWER.

BY HOLROYD SMITH.

(*Continued from page 39*).

As the term "lines of magnetic force" are "Greek" to those unacquainted with electrical science, it will perhaps be well to try and explain what takes place by the use of mechanical terms and illustrations (see next page).

Let A, Fig. 1, represent a drum or barrel with two long cords wound round it, the end of one cord passing round the pulley in the box S, the end of the other round the pulley in the box N. Now, if weights be attached, the cords will be pulled off the drum, making it revolve. Notice they are always pulling from the points, N and S. This may be taken as illustrating the magnetic attraction. Referring to Fig. 2, if A is a little water-wheel placed between two pipes, S and N, connected to a cistern full of water, and the water be allowed to flow from the spouts and impinge on the water-wheel, it would be forced round as long as the watersupply lasted. This may be taken as illustrating the magnetic repulsion.

If now we make the cistern a mass of iron and the pipes bars of iron, wound with copper wire, and put heavy masses of iron at the bottom, shaped as shown at S and N in Fig. 3, and instead of the pulleys or water-wheel we take an iron ring or cylinder also wound with copper wire, and allow a current of electricity to pass through the wire, the iron will become magnetic and the armature, A, will revolve in the direction indicated by the large arrows, because the magnetic force is acting as indicated by the little darts; the dotted darts represent the repelling action, the other darts the pulling action. The movement of a conductor in a magnetic field is omitted as too technical for this article. From this hasty survey of first principles, it will be seen, as stated at the commencement, that electricity can be produced without the use of chemicals for the decomposition of metals. Mechanical work can be turned into electricity, and electricity can be turned into mechanical work.

There have of late been so many exhibitions, not only in London, but also in the chief provincial towns, all of which have been lighted by electricity, that little need be said as to the display that can be produced by the electric light. In Manchester, last year, the brilliant illumination of the main building by arc lamps, the wonderfully charming fairy fountain in the grounds, and the cheerful homely light of the incandescent lamps in the numerous examples of house furnishing, show conclusively what can be done. And it is natural to ask, how is it that electricity is not more generally adopted for everyday use, if it possesses the many advantages claimed for it? The answer is, because all English people, whatever their political creed, are very conservative, and are slow to take up anything that is new. Again, we are so hedged about with vested interests and monopolies that it is difficult for new enterprises, needing public support and use, to get any foothold. In addition to this, until lately all electrical enterprise has been held in by the curb and snaffle of a prohibitive Act of Parliament, and therefore up to the present the successful installations are those undertaken by people able to pay for them, and using them on their own premises. As an example of this may be cited the Great Western Railway station, Paddington, the Grosvenor Gallery, London, and Wentworth Castle, the property and residence of T. G. F. Vernon Wentworth, which is, perhaps, the largest private installation in this country that has attracted the attention of electricians. One of the scientific papers, after giving full technical details, thus describes the lighting:

"The castle being a place of historic interest, full of valuable paintings and other objects of attraction, some further detailed description of the lighting of the principal rooms may be interesting. Commencing with the east wing, on the upper floor is the picture gallery, extending the whole length of the wing, 170ft. long and 24ft. broad, proportionately high, and is considered to be one of the largest in Yorkshire. The building being of a classical style, the walls are divided by numerous pilasters supporting the architraves which run round, and there are arches near each end, resting on white marble. This is lighted entirely with side lights from brackets of light and special design, in appearance resembling the stalks of flowers rising from a group of leaves and drooping over. Leaves of chased brass are placed at intervals on the stem, which terminates in a globular frosted glow lamp, specially made for this installation. The effect is heightened by mirrors placed between the pilasters, the lights on either side of these bending gracefully forward so as to be reflected. There are 107 lamps in this room; the appearance of the lights hanging from their graceful stems, either singly, double, or in groups like bunches of fruit, is exceedingly pleasing, if not unique. The pictures are well lighted, and the whole is seen to great advantage. Omitting the remainder of the upper rooms, we descend the grand staircase, which is lighted by a 7-lamp electrolier, and enter the Strafford Room, which is lighted by eight side lights. The walls of this room are lined with valuable pictures, as, indeed, are all the rooms on the ground floor,

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of the east and south wings. Next follows the dining-room, lighted by twelve side lights, and also by a pendant electrolier for the dining-table, etc., containing three groups of lamps under three dome shades, which are capable of sliding backwards and forwards, and connecting with a centre by cone bearings, so as to allow of a rocking action in the electrolier when being drawn in one direction or the other. The weight of the electroliers is carried by insulated pulleys on an independent travelling line. This makes a most effective and brilliant way of lighting a dining-room table. Following on is the grand hall, decorated in white and gold, lighted by 16 side lights. These are for the most part placed in front of mirrors, and on light descending stems proceeding from lions' heads, in keeping with the other decorations. It may be here remarked that the whole of the east wall of this storey is decorated with mirrors, which have lights on each side of them. The lower floors of the eastern wing consist of several libraries and sitting-rooms, which are lighted with side lights on brackets of varied designs.

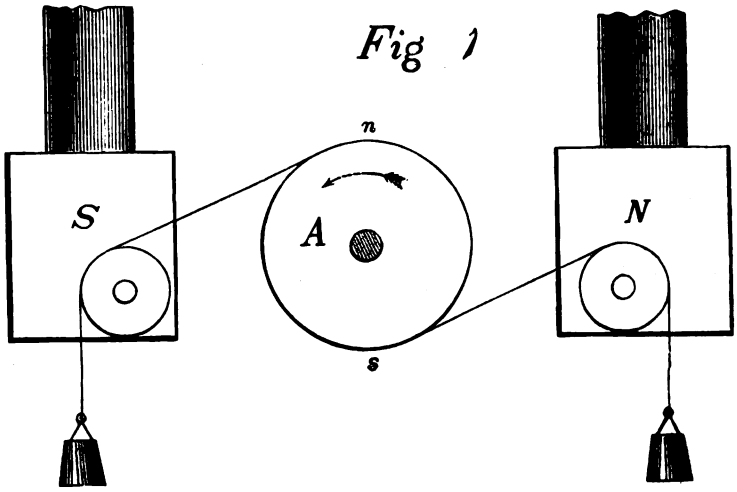
"The upper rooms, known as the Swan, Roman, Canopy, and Ark, are lined with tapestry (doors included), which is said to be unsurpassed. These are all lighted by side pendants of various colours, suspended from brackets above the tapestry. These rooms being also furnished as sitting-rooms, there are double-jointed brackets on either side of the fireplace for convenience of reading, as there are also in many other rooms. Referring to the other parts of the house, it may be remarked that the whole is well lighted, the kitchen, for example, having six pendant lights.

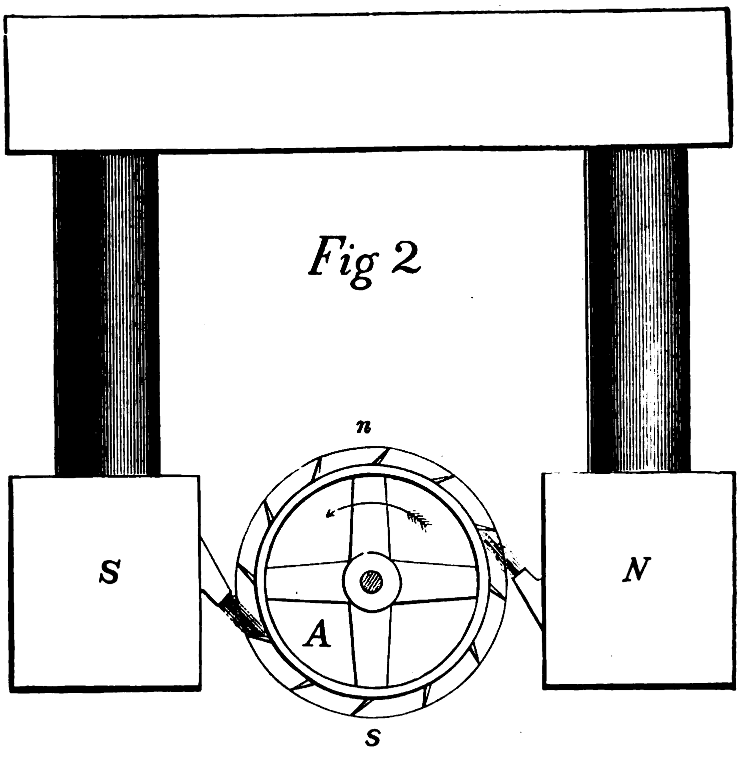
"The conservatory is lighted up for reading and writing, and for lunching, the effect of the light amongst the ferns and flowers, orange trees and foliage, being charming. There are sundry outside lamps for lighting up the approaches. The outside premises consist of a steward's house, stables and coach-houses, cow-houses, and farmyard; also the laundry, dairy, &c., with other appurtenances. . . . . .

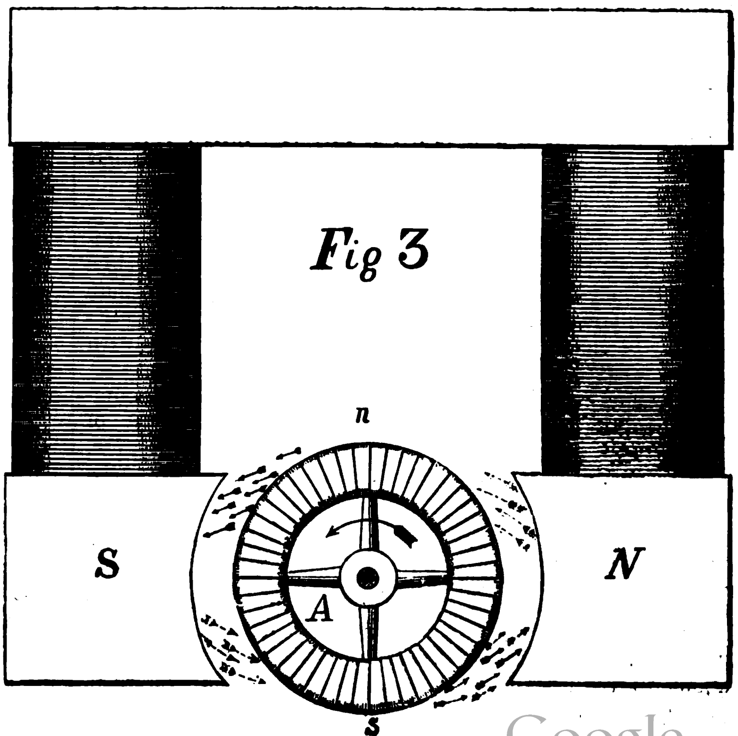
"The greatest care has been taken not only in the general arrangement, but in all the details, from the boilers to the lamps, to make it as perfect as possible in every respect, everything being of the best quality. In addition to the special arrangement for the simplification of the switches, complete instructions, mounted and framed, are placed near each switchboard; in short, the utmost pains are taken to make the whole most simple and intelligent. The installation was completed in December, 1885, and has run ever since without a hitch of any kind, and that, too, without the supervision of any electrician or anybody beyond those already employed on the estate. These facts are of the greatest importance, proving that the electric light can be so arranged as to be perfectly trustworthy, easily and inexpensively managed, and to give no trouble whatever. Its advantages as compared with the paraffin lamps, candles, and lanterns previously used are immense, and with such an example of beauty, brilliance, and elegance it is to be expected that ere long we shall see many of the large and historical mansions similarly lighted, and in this way the owners will secure for themselves the greatest comfort, convenience, and pleasure, whilst adding to their historic treasures that which is one of the greatest triumphs of the present century."

Hatfield House, the residence of the Marquis of Salisbury, now Prime Minister of England, may be taken as another example. Electric motors pump the water from the river to cisterns in the roof. Electric motors drive the circular saw and other machinery used at the homestead, and all the mansion is beautifully lighted with electric lamps. No smoke, no smell, no matches, very little risk of fire; just press a button, turn a knob, or pull a cord, and the whole room, corridor, hall, gallery, alcove, tower, or vaults are lighted as if by magic.

We are, indeed, realising "the fairy tale of science and the long results of time." Now, the surgeon, instead of groping in darkness or imperfectly reflected light, can pass a tiny electric lamp down the patient's throat, and see what is required. In Paris ladies frequently wear electric glow lamps in their hair, or as glittering dewdrops on artificial flowers, and the crowns of pantomimic fairies are often ablaze with electric diamonds; but, perhaps, the most effective use of electricity for dramatic purposes was when Irving, as Mephistopheles, watching the duel between Faust and Valentine, thrusts his sword between the combatants' swords, and, as they touch, blue sparks glint and







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crackle, or when, in the Brocken scene, the little imps gambol about his knees, and, as he caresses them, bright flashes as from another and a lower world follow his hand.

All the illustrations given are for luxury or for the hope of gain. There are very few in this country for public utility. Perhaps the best example is on some of our lighthouses; yet though we have two at Dover, they are far surpassed by the light tower at Calais, where the three immense rays of revolving light sweep both land and sea in turn.*

(*To be continued.*)

ELECTRIC METERS FOR CENTRAL STATIONS.†

BY PROF. GEORGE FORBES, F.R.S.

There is no department of electrical engineering which has interested me and occupied my thought more than that of central station work, and the distribution of electricity from these centres throughout a town for the production of light and power.

It was before this society that I had the honour of classifying and developing the systems of distribution at the disposal of the engineer.‡ The position in which we now find ourselves is that, for extremely concentrated areas, a direct supply with continuous current dynamos, sometimes assisted by secondary batteries, and working on the three-wire system, is the most successful and the most remunerative; but for extensive areas the use of high-tension alternating currents in our mains, reduced in the houses by means of induction apparatus, is the most economical and flexible. This is the system which was first published and used by Gaulard and Gibbs. To take examples in the City of London. While we recommend the adoption of high-tension alternating currents by a company which is preparing to supply the whole of London with electric light, yet I felt that for the concentrated area bounded by Pall-Mall, Green Park, Piccadilly, and Haymarket it was far best to recommend the low-tension three-wire system; and we may look forward to seeing that central station the most satisfactory in the world from every point of view. This is owing to its concentrated area, and the large consumption of light in the district.

It always seemed that the success of such central stations depends largely on the working out of details in the arrangements—details in the mechanical parts, details in the electrical parts; and I have seldom visited any such stations without seeing new points of detail, and learning new facts about the causes which lead to success and failure.

In order that we may make as few mistakes as possible in our central station work, one must try to learn as much as possible from countries which have made a greater start than England. Thus I was led to visit the stations established on various systems in the United States; and lately I have done the same thing with respect to the most important of the central stations in Europe.

Both in Europe and America there is one maxim which I find is conclusively established. This is that the best paying stations are those in which the electricity is charged for by meter, and not at so much per lamp per annum. Both these systems are in use, but companies who have used both give their undivided testimony in favour of charging by meter.

I propose to deal with this important point of detail to-night, and to tell you something about the working of different types of meters in the United States as well as in Europe.

Now, first let us settle the question what it is we want to measure. Both with gas and with electricity, if the company supplies burners or lamps it would be most desirable to measure the light given off. But this plan is not likely to be adopted in England. The private consumers generally supply the burners or the lamps. Hence, what we come to is that we want to measure the gas or the electricity consumed. We want to measure its light-giving power. To do this we must know the quantity consumed and its quality. With gas, the latter is impossible to measure in the meter. We can only measure the quantity of gas consumed. We cannot measure its pressure nor its purity, nor the quantity of air or sulphur combined or mixed with it. These points are left to inspectors to determine, who shall insist upon a standard being maintained.

With electricity it is different. When we have measured the quantity consumed there is only one quality which can exist, and that is its pressure. If, then, our meters measure the quantity consumed, and inspectors keep watch to see that the pressure is always maintained constant, the consumer's interests are amply looked after.

Now it has been suggested that we really ought to measure, not the quantity of electric current which is consumed, but the quantity of energy. Now, the energy is the product of the quantity by the pressure, and could easily be measured if desired. There would be no object, however, in doing this. A deficiency of pressure is certainly undesirable, because the lamps burn less brightly, and the customer should be charged less. But, on the other hand, an excess of pressure is equally objectionable, because it injures the lamps, and it would not be fair to charge the customer more for the quantity he uses under these conditions. The only fair way is to do as with gas—*i.e.*, to measure the quantity used and guarantee the quality—*i.e.*, the constancy of pressure. This should never vary more than 4 or 5 per cent. at the most. For perfect lighting a variation of 2 or 3 per cent. only can be allowed.

I intend to direct your attention to various kinds of meters which have been put into actual practice, but before doing so it will be well to point out some of the desiderata in a perfect electric meter. I will deal with these in order.

1. *Accuracy.*—The meter must be at least as accurate as an ordinary gas-meter. In fact, that standard is rather low for modern requirements. The question of accuracy is two-fold. First the readings of the meter must be accordant for all rates of supplying electricity within its range, and secondly, the indications of different meters must be consistent. This latter point is largely one of manufacture, so that it must be easy to manufacture the instruments in large quantities, all exactly similar.

2. *Range.*—It is desirable that the meter should be capable of working accurately over a large range of current strength. It would undoubtedly be desirable that the meters, made for the largest currents which can be used on a circuit, should also be capable of indicating correctly when only one lamp is in circuit. So far as I am aware, no electric meter has been invented fulfilling this requirement. It has often been proposed, with circuits of very many lamps, to have two meters—one for small currents, and the other for large ones—and to switch in the latter automatically when the current exceeds a certain amount. Any such arrangement which involves an occasional use of a contact-breaker is objectionable, owing to the sparking and consequent deterioration of the contact. A far better plan, in the existing state of things, is to wire the houses in separate circuits of 20, 40, 60, or 100 lamps, according to the effective range of the meter adopted.

3. *Consumption of Energy.*—Energy must not be consumed by the meter to such an extent as to diminish injuriously the voltage supplied to the lamps. The wiring of a house diminishes the voltage at the maximum about 2 per cent., according to present practice. A meter ought not to increase this loss by more than ½ per cent.

4. *Simplicity.*—The meter should be simple to construct, and not liable to get out of order. Extreme delicacy in moving parts is to be avoided when possible.

5. *Durability.*—It is essential that no parts of the apparatus are liable to wear out rapidly.

6. *Attention.*—Other things being equal, that meter is the best which requires least attention. Any winding up of clockwork is objectionable, and the necessity of removing the meter or part of it from the consumer's premises should be avoided.

7. *Registration.*—The meter should register in a clear manner, so that the consumer can read it at any time and check its accuracy. A system of geared wheels with indexes and pointers, like a gas-meter, is very convenient.

8. *Testing.*—A point of some practical value is that it should be an easy matter to test the meter, and that the operation should not occupy much time.

9. *Cheating.*—With some meters the process of cheating is easier than with others. The possibility of short-circuiting the meter is common to all, and can be obviated. Some meters can be retarded by placing a magnet near them, others by heating them, others by putting them out of level. This last can be prevented by securely fixing the meter to a wall or floor.

10. *Economy.*—A meter will not be practical if it entails a large rental, and so adds much to the quarterly bill.

11. *Freezing.*—A meter which contains a liquid which can freeze is objectionable in any but warm countries, since a lamp or other resistance must then be put inside it to keep it warm, and this is a constant source of waste of energy.

12. *Alternating and Continuous Currents.*—Some meters are only usable with continuous, others with alternating, currents. A meter which reads with equal accuracy for both kinds has a double value. Many stations supply both classes of currents, and it is less inconvenient to deal with only one type of meter.

13. *Number of Alternations.*—Meters for alternate currents ought to indicate with equal accuracy, whatever be the alternations per second. Otherwise irregularities will occur, and also the supplier of electricity can cheat by altering the number when under test, and also when at actual work.

14. *Contact-breaking.*—No contact-breaker of any electric circuit should be allowed in a meter, because such contacts deteriorate with use.

15. The meters should be so substantial that they can be sent by rail without accident.

No one meter fulfils all these requirements perfectly. But

* In one respect we do surpass our neighbours, viz., in the employment of powerful electric lamps as search-lights on most of our men-of-war. † Paper read before the Society of Arts, January 23. ‡ Cantor Lectures, 1885.

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all the meters which I am going to describe fulfil many of them, as they all have done good practical work on central stations.

In all the meters which I have to describe the registration is effected either by moving mechanical parts or by electrolytic decomposition. In most of the mechanical meters a certain dynamical principle has been employed to guide the inventors to an accurate instrument for different strengths of current. I will now explain this. In the class of meters I allude to the electric current sets some mechanism in movement. Now, we all know that generally the work done by a current in a given time varies as the square of the current. Thus, the electrical force tending to drive the mechanism is proportional to the square of the current. Such mechanism would increase its speed indefinitely under the influence of such a force if there were no friction opposing the increase of speed. In the meters I allude to the friction of the air or of a fluid is opposed to the driving force of the electric current. This resistance increases as the square of the velocity. The electric force goes on increasing the speed of the mechanism until the opposing friction equals the driving force of the electric current. But the friction varies as the square of the velocity, and the driving force varies as the square of the current. Hence in all cases where the mechanism acquires uniform speed, the square of the velocity is proportional to the square of the current—in other words, the velocity varies as the current. Now, the indications of such an instrument as shown by an index gives the number of revolutions of the mechanism in the period of testing, which means the velocity multiplied by the time, and this is proportional to the electric current multiplied by the time. Hence, the index marks the total number of ampere hours, or the total number of Board of Trade units which have passed through the instrument.

Edison Meter.—In describing the different meters, I will begin with the Edison meter, not only because it was the first to be used, but also because it has done a larger amount of useful work in central stations than any other meter. In its original form, as shown in the Paris Electrical Exhibition, in 1881, it consisted of two copper plates suspended from the two ends of a balanced beam in a solution of sulphate of copper. A continuous current passing through from one plate to the other decomposed one plate and deposited copper on the other. This one eventually got heavy enough to tip over the balanced beam. This mechanical action had two effects, (1) it registered a unit on the counting mechanism, and (2) it reversed the direction of the current, and now the lighter plate received the copper deposit, and so the process went on continuously. It was not possible to pass the whole current in this way through the solution, because the resistance would be too great. Hence the depositing cell was put as a shunt on the main current. Several objections to this type soon became apparent in practice: (1) When the temperature of the air was high, the resistance of the solution diminished, while the resistance of the alternative metal path increased. Hence with high temperatures a greater proportion of the total current went through the meter. (2) It was soon found that a make and break, as necessitated by the reversals in the direction of the current, led to endless trouble, and the ingenious method of counting had to be abandoned. In the improved meter, zinc is the metal employed, and sulphate of zinc the solution. The current always goes in one direction. Fresh plates are inserted as they wear away. To determine the consumption of electricity, the meter is carried away and the loss of zinc in the positive plate is weighed, and the consumer charged for a proportionate number of units of electric current; 1-1,000th of the total current passes through the zinc solution. In series with this solution is placed a copper resistance, so arranged that with a rise of temperature the fall in resistance of the solution equals the rise in resistance of the copper, the alternative path being of german silver. Thus between 4deg. and 34deg. C. the same fraction of the current passes through the solution. To prevent freezing, an incandescent lamp is always kept burning in the case containing the meter during the months that freezing is possible.

The range within which the meter is said to be accurate within 3 per cent. is from 5-fold to 10-fold—*i.e.*, if one ampere is the lowest current for which it is accurate, then 5 or 10 amperes is the maximum current for which it is accurate.

Now, you may say that this is not exactly the kind of meter we require, because customers cannot check the weighings, and are absolutely dependent on the good faith of the company supplying the electricity. It has also been argued that the shunt arrangement cannot be perfect with varying temperatures. Well, I can only say that the meter in practice is found to do good work. I agree entirely with what Mr. Edison said to me about it. He said: "It is not an ideal meter, but it is simple and effective, and gives general satisfaction wherever it is used." I endorse this opinion. But the managers of central stations where it is used have given me higher estimates still of its value. They say that customers are all quite content with the manner of reading it. As to accuracy, many customers have kept accurate tally of the lamp hours which they have consumed, and compared it with the charges by meter, and have often come within 2 or 3 per cent. At the splendid central station at Milan, which I lately visited, this meter is in constant use, and is much appreciated by the company. They say that the expenses of maintaining the meter department are not large when the whole thing is well organised. The total number of ampere hours sent out from the station, as measured by the ampere-meters, agrees with the meter accounts within 3 per cent. This station, which I have carefully inspected, is an admirably conducted one, and embraces three systems—the Edison low tension, the alternating high tension, and the Thomson-Houston arc lamp systems.

(To be continued.)

THE INSULATION RESISTANCE OF ELECTRIC LIGHTING INSTALLATIONS.*

BY PROF. A. JAMIESON, F.R.S.E., M.I.C.E., MEMBER.

Insulation Resistance of Land Lines and Submarine Cables.—In the early days of telegraph land lines and of submarine cables, *insulation resistance* was neither definitely specified for, nor accurately measured during the various processes of manufacture and maintenance. A few failures, however (in some cases dearly bought), soon impressed electricians with the necessity for paying more attention to this important quality, and they were not long in demanding from contractors the minimum of insulation resistance which would enable their lines to be worked with success. Not only are careful insulation tests now made during the manufacture of insutators and the erection of the land lines under the British Postal Telegraph Department, but "daily tests" are taken of all the more important lines. The minimum insulation resistance which each insulator should have depends upon the length of the line. For a line of 100 miles long, each insulator is expected to give a resistance of 500 megohms, whereas for a line of only ten miles 50 megohms is considered sufficient. When a line has been erected and put into working order, it is usual to fix upon a minimum standard insulation resistance per mile. If the measured value at any time falls below this standard, then the line is considered faulty, and steps are taken to remove the fault. The Post Office standard is 200,000 ohms per mile. In the cases of subterranean land lines and of submarine cables, an even still more rigid and careful system of inspection and of testing is now carried out during the manufacture of the cores and cables. The results are invariably reduced to an insulation resistance per unit of length at a standard temperature. The following extract from the specification of a successfully made and laid cable will serve to illustrate this: "The insulation resistance per knot of the gutta-percha core shall not be less, when tested at 75deg. Fah., than 300 megohms, 14 days after manufacture and after two minutes' electrification. If the resistance of any portion of the gutta-percha (reduced to 75deg. Fah.) at any period of the manufacture fall below the above specified limit, the cable to be rejected." Throughout the whole of the operations of coiling and uncoiling a cable into the shore and ship's tanks, during the laying, and for ever after during its existence, the insulation resistance is periodically measured and tabulated.

Results of Neglecting Insulation Resistance in Electric Lighting.—We have been induced thus to particularise the extreme care and attention which is now considered so absolutely necessary in the case of land lines and of submarine cables, because the industry of electric lighting has just passed through a similar experience to that which these industries met with in their earlier days. When the industry of electric lighting was first beginning to take root in this country, electric light engineers pooh-poohed the idea of accurately measuring the insulation resistance of any part of their work, and they invariably turned a deaf ear to the timely warnings of telegraph engineers and electricians. Experience has, however, taught them, as it did their elder brothers, that good uniform insulation resistance throughout an installation is of immense importance, and that it cannot be obtained without careful attention to details and a rigorous system of testing during manufacture, erection, and after completion. If an installation is not well insulated throughout, leakage of the current takes place, and consequently waste of power and money; electro-chemical action sets in where damp or liquids are present, and the conductor is thereby eaten through or a short-circuit occurs, which for a time stops the whole of the lighting. Discredit thus not only falls upon the contractor, but others are frightened from employing the electric light, to the detriment of the industry as a whole.

Necessity for Discussing a Standard of Insulation Resistance.—The terms usually employed in regard to the insulation resistance of an electric light installation are that it shall be "good" or "perfect," according to the fancy of the party purchasing the plant or of his adviser. These terms have, however, no specific meaning, and are therefore very variously interpreted. No doubt the society has had this subject before them in committee when drawing up their set of rules for the "prevention of fire risks"; but the Institution as a whole has never had an opportunity of discussing it, and thereby of impressing its members and the public generally with its importance, and the necessity for observing some minimum standard of insulation resistance. The writer had his attention directed the other day to a communication read before the International Society of Electricians, Paris, in November last, by M. Picou, wherein that gentleman ably analysed this question, and proposed a rule based upon tests of short lengths of cotton-covered insulated wire. He has not had an opportunity, however, of learning the extent and the nature of

* Paper read before the Institution of Electrical Engineers on Thursday, January 24th, 1889.

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the discussion upon M. Picou's paper, and he can only, therefore, place his rule before the members, along with a few other rules, and leave them to form their own opinions, guided by their practical experience.

General Propositions.—The following points will no doubt be readily admitted in regard to insulation resistance of electric lighting installations:

1. That owing to the comparatively low resistance of the conductor circuit of ordinary electric light installations on the parallel incandescent system, the minimum standard of insulation resistance does not require to be nearly so high per unit of length as in the case of submarine cables.
2. That it should be directly proportional to the E.M.F. of the generator, or difference of potential between the conductor and earth or between the forward and return conductors.
3. That it should be inversely proportional to the total length of insulated conductor, or to the total current, or to the number of lamps in circuit.
4. That, whatever rules or standards of insulation resistance may be adopted, they should be applied, not only to all the conducting wires, but also to the dynamo, the lamps, and all the fittings, or, in other words, to the *whole* circuit.

Rules.—1882 Set of Rules by Society of Telegraph Engineers and Electricians.—In May, 1882, in the first set of "Rules and Regulations for the prevention of fire risks arising from electric lighting" issued by the Society of Telegraph Engineers, no standard of insulation resistance or of minimum leakage is recommended. All that we find there on this head is: "The difficulties that beset the electrical engineer are chiefly internal and invisible, and they can only be effectually guarded against by testing or probing with electric currents"; "All wires used for indoor purposes should be efficiently insulated," etc.; "The insulation of dynamo coils and conductors should be practically perfect"; "The value of frequently testing the apparatus and circuits cannot be too strongly urged," etc.

Four years ago, even, the writer is not aware that any published rule existed, or that any specification contained any definite rule for the insulation resistance of any part of any electrical installation.

Admiralty Rule.—About 1883 or 1884, however, the Admiralty officials requested that the insulation resistance of the dynamos supplied to them should withstand the test of stroking the free end of a conducting wire (the other end being connected to either pole) over any part of the framing without showing any signs of a sparking when the machine was driven at its normal speed. The writer does not know whether they still insert this rule in their specifications, or whether they have modified or improved it; but at best it is only a rough-and-ready test, and gives no indication whatever as to the precise locality of a fault or its value in ohms.

Workman's Tests.—The only test applied by contractors when wiring an installation was, and often still is, that of simply inserting

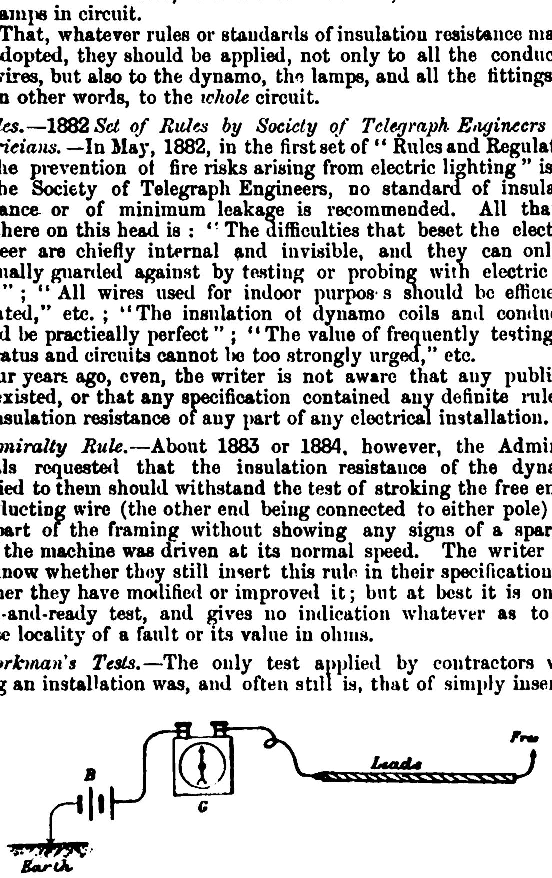

Fig. 1.

an ordinary lineman's detector or galvanometer, G, between a battery, B (of one or two cells), and the leads, with the other end or ends freed, as in Fig. 1. If the galvanometer gives no deflection, or a very small one, then the section is passed as all right.

This is such an exceedingly simple and handy test for workmen that it can scarcely be improved upon, but it gives no precise indication whatever of the resistance in ohms, of the dielectric, or of the fittings. It simply informs the observer whether there is a bad fault or not. He can also find out by it whether the continuity of the conductor is complete, by earthing the further end; and he can also ascertain whether there is a short-circuit or not between any two or more "forward" and "return" leads by connecting up his apparatus as shown in Fig. 2.

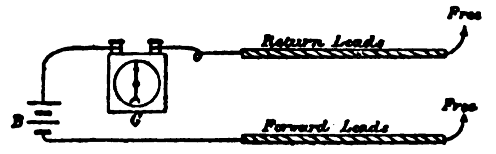

Fig. 2.

In 1884 Messrs. Wm. Denny and Bros.' electrician used a small portable magneto-electric machine and sensitive bell—the same as telephone companies employ—instead of the above-mentioned galvanometer and battery. If the bell rang, a fault existed, and its position had to be found out; if it did not, then all was supposed to be right. He, however, in addition to this merely workman's test, applied a more exact test by Wheatstone bridge, and thus obtained the insulation resistance of the whole or of any desired portion of the circuit and the fittings in ohms.

Prof. Jamieson's Rule.—In 1884, whilst testing the electric light wires and fittings of some ships, the writer first drew up his rule, which has been published in the last three editions of Munro and Jamieson's "Pocket Book of Electrical Rules and Tables." He had previously (since 1881) tested, by Wheatstone bridge, etc., the insulation resistance of a number of land and ship installations, and was rather surprised at the variety and lowness of the dielectric resistance, for his ideas of insulation resistance had been somewhat magnified by seven years' experience with submarine cables. At first, he could not get contractors to come up to his rule, but he was much gratified about this time by the enthusiasm and interest which Messrs. W. Denny and Bros.' electrician took in the matter, and by finding such good results in his tests of their ships' lighting leads, which results so far surpassed the demands of his rule that he decided to adhere to it. Since then he has had much less difficulty, and when care and attention to cleanliness in jointing, to the fixing of wires and fittings, as well as in the manufacture of dynamos, are observed, he has frequently found that the insulation exceeded the demands of his rule, which is as follows: "A careful insulation resistance test of each circuit, and finally of the whole of the circuits (including all switches and terminals, but not necessarily the lamps) joined up together, should be taken by the method described above,* and not passed unless the resistance is at least equal to ·1 Ω per lamp for every volt employed. The insulation resistance of the dynamo coils should be equally good.

Put into formula shape, the rule is—

$$R_I = k\frac{E}{N_L},$$

where R_I = the total insulation resistance of the whole or any part of the lamp circuits or of the generator in ohms;
k = a constant (·1 Ω = $\frac{1}{10}$ Ω = 100,000 ω) found from actual tests of several well-erected installations;
E = E.M.F. of dynamo or installation in volts;
N_L = number of lamps (16 c.p.) on each circuit or on the whole circuit.

The insulation resistance is therefore here taken to be *directly* proportional to the normal E.M.F. of the dynamo, and *inversely* proportional to the number of 16 c.p. lamps in circuit. The difficulty of ascertaining the precise length of the mains, sub-mains, leads, and dynamo windings led the writer to substitute the number of lamps in circuit for what might at first sight appear to be the more exact term in the denominator—viz., the length of conducting wires employed. Although not stated in the above quotation of his rule, the writer usually applies the same test for the resistance or percentage leakage of current between the whole system of forward and return wires; also between the dynamo armature with field-magnet coils in circuit and the frame or body of the machine, as well as between the series and shunt-magnet coils if the dynamo is of the compound or series-shunt type.

The following example and table will make the application of this rule clearer:

Suppose that we have an installation of 100 lamps of 16 c.p. each, and that the normal difference of potential between the terminals of the dynamo is 100 volts, then the insulation resistance should not be less than

$$R_I = k\frac{E}{N_L}$$
$$= 100{,}000\,\omega\,\frac{100\,v}{100\,L}$$
$$= 100{,}000\,\omega = \cdot 1\,\Omega.$$

Table of Insulation Resistances required by Jamieson's Rule. For 16 c.p. Lamp Circuits and Dynamos.

Number of lamps in circuit.	50-volt lamps.	65-volt lamps.	80-volt lamps.	100-volt lamps.	110-volt lamps.
	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.
1	5,000,000	6,500,000	8,000,000	10,000,000	11,000,000
10	500,000	650,000	800,000	1,000,000	1,100,000
20	250,000	325,000	400,000	500,000	550,000
40	125,000	162,500	200,000	250,000	275,000
50	100,000	130,000	160,000	200,000	220,000
100	50,000	65,000	80,000	100,000	110,000
150	33,333	43,333	53,333	66,666	73,333
200	25,000	32,500	40,000	50,000	55,000
300	16,666	21,666	26,666	33,333	36,666
400	12,500	16,250	20,000	25,000	27,500
500	10,000	13,000	16,000	20,000	22,000
1,000	5,000	6,500	8,000	10,000	11,000

The leakage allowed by this rule in the case of 100-volt lamps, using ·64 ampere of current per lamp, is

$$C=\frac{E}{R}=\frac{100\,v}{10{,}000{,}000\,\omega}=\frac{1}{100{,}000}\text{ ampere of leakage}$$

for every lamp in circuit. Each lamp, however, requires ·64 ampere; consequently the leakage = $\frac{1}{64000}$ part of the total current.

Or, the percentage leakage = $\frac{1}{640}$ = ·0016%.

Since by the above rule the dynamo requires to have the same insulation resistance as the lamp circuit, the insulation resistance of the *whole* circuit, including the dynamo, is half of that given by the formula and tables, and therefore the leakage is double, or $\frac{1}{32000}$ part of the total current, or $\frac{1}{320}$% = ·0032%.

* See Munro and Jamieson's "Pocket-Book of Electrical Rules and Tables," p. 179, at foot. This rules applies only to the dynamos, leads, and fittings for incandescent lamps arranged on the single parallel system. Should the lamps be arranged in parallels, with two or three or more lamps in series in each parallel, they count as but one for each parallel.

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Phœnix Fire Office Rules.—In May, 1888, in the thirteenth edition of the Phœnix Fire Office Rules, Mr. Heaphy recommends that "in any electric light installation in which the current is continuous, and has an electromotive force of 200 volts or under, the insulation resistance over the whole circuit inside any buildings should never run below 10,000 ohms. . . . With currents of 1,000 volts the insulation resistance should never drop below 50,000 ohms, no matter how wet the weather may be. For alternate currents the minimum insulation resistance should be twice the above number of ohms respectively."

In November, 1888, in the fourteenth edition, Mr. Heaphy is more precise, and he has added a table based upon similar proportions to the writer's rule.* His Rule No. 27 reads as follows: "In any electric light installation in which the current is continuous, and has an E.M.F. of 200 volts or under, the insulation resistance over the whole installation should not be below the following:

"Installations of	25 lights	......	500,000 ohms.
,,	50 ,,	......	250,000 ,,
,,	100 ,,	......	125,000 ,,
,,	500 ,,	......	25,000 ,,
,,	1,000 ,,	......	12,500 ,,

When the lights are proportionate between the above numbers, then the insulation resistance should be correspondingly proportionate. The insulation resistance of separate circuits of the installation should also be taken, and should be in accordance with the above table. For alternate currents the minimum insulation resistance should be twice the above number of ohms respectively."

Objections to Phœnix Rule.—The following objections may be offered in regard to this last rule:

1. It ties down a contractor to one and the same insulation resistance whether the E.M.F. of the installation lies anywhere below 200 volts. Surely a 50-volt installation requires but half the insulation resistance of a 100 volt one, and but one-fourth that of one with 200 volts.
2. It is somewhat doubtful (owing to a previous note to Rule No. 20) whether the words "over the whole installation" include the dynamo as well as all the wires, fittings, and lamps.
3. No distinction is made between cir cuits with one, or two, or more lamps in each parallel.
4. Arc lamps of 2,000 c.p. or more in parallel, and large incandescent lamps of 500 c.p. or more, which require strong currents, come under the same general words, "any electric light installation in which the current is continuous," just as much as small incandescent lamps of, say, 5 c.p., which require only a fraction of an ampere.

A question naturally arises here for discussion, Should not the insulation resistance in such extreme cases bear some definite proportion to the current?

Westminster Fire Office Rule.—In 1888 the Westminster Fire Office issued a set of rules for guiding their officers in regard to electric light installations, in which they demand that the insulation resistance shall in no case be less than 150,000,000 ohms per mile! Surely they have been blindly making extracts from a submarine cable specification! No contractor could be expected, under ordinary circumstances, to complete his work (including dynamo and fittings) to such a high standard.

M. Picou's Rule.—On November 7, 1888, M. Picou communicated his rule to the International Society of Electricians, Paris.† Using the same symbols as in the writer's rule, it is—

$$R_I = k\frac{E}{C},$$

where R_I = the total insulation resistance of the circuit in ohms;
k = a constant (500) found by experiments with short lengths of wire covered with three layers of cotton wound in reverse layers and pressed between metal plates;
E = maximum E.M.F. of the generator in volts;
C = total current generated or passing through circuits in amperes;
$\frac{E}{C}$ = the resistance in ohms of the whole circuit when the installation is in full working order.

The differences between M. Picou's rule and the writer's lie in the different values given to the constant, k, and in the substitution by M. Picou of the total current, C, for the total number of lamps, N_L, in the writer's rule. There is no doubt an advantage in thus substituting C for N_L, since the constant, k, thereby expresses directly the number of times the insulation resistance is of the apparent working resistance, $\frac{E}{C}$. And its reciprocal, the proportion which the leakage current bears to the total current. For, let c = the leakage current, and adopting the same symbols as above for the other terms, then

$$c = \frac{E}{R_I} = \frac{E}{k\frac{E}{C}} = \frac{C}{k},$$

$$\therefore \frac{1}{k} = \frac{c}{C} = \frac{\text{leakage current}}{\text{total current.}}.$$

* It will be observed that the above table corresponds identically with the writer's rule for an E.M.F. of 125 volts; *e.g.*, take 100 lamps; then

$$R_I = k\frac{E}{N_L} = 100{,}000\ \omega\frac{125\ v}{100\ L} = 125{,}000 \text{ ohms};$$

and so on in proportion to the number of lamps.—A. J

† See *Electrical Review*, Nov. 23, 1888.

We, however, consider that M. Picou's constant, 500, is by far too low to ensure good and lasting work. By it a circuit of 1,000 lamps of 16 c.p. each, requiring 100 volts and ·64 ampere each, the total insulation resistance of the circuit would only need to be 78·1 ohms, instead of 10,000 ohms by the author's rule (or 5,000 ohms if the dynamo be included).

The Society of Telegraph Engineers and Electricians' Last Rule.—In April, 1888, this society issued its second pamphlet of "Rules and Regulations for the Prevention of Fire Risks," and Rule 16 states that "the insulation of a system of distribution should be such that the greatest leakage from any conductor to earth (and in the case of parallel working from one conductor to the other when all branches are switched on, but lamps, motors, etc., removed) does not exceed $\frac{1}{5000}$ part of the total current intended for the supply of said lamps, motors, etc., the test being made at the usual working E.M.F." This rule includes all kinds and systems of electrical installations, and it is very neatly and concisely expressed. Some persons have, however, a difficulty in understanding how the $\frac{1}{5000}$ part of the total current is to be tested for or ascertained, and others do not see exactly how the test is to be applied to different parts of the circuits at the usual working E.M.F. *before* the installation is put into working order.

If the rule had also been put into the following form, with a table giving the insulation resistances required for a few of the more common E.M.F.'s and currents (or number of lamps), it would no doubt have recommended itself more readily to those unaccustomed to deal with the form of expression used in the rule. Using the same symbols as before, we have—

$$\frac{1}{5{,}000}C = c = \frac{E}{R_I},$$

$$\therefore R_I = 5{,}000\frac{E}{C} = k\frac{E}{C},$$

which is the form of expression used before, and most easily applied. This gives a constant ten times as great as M. Picou's, and about one-tenth that of the writer's rule. Which of these constants is most in accordance with good practice?

Table of Insulation Resistances required by the Society of Telegraph Engineers and Electricians' Last Rule—viz., the leakage of any part of an installation not to exceed* $\frac{1}{5000}$ *of total current supplying that part; or,* R_I = 5,000 E/C.

Number of amperes in circuit.	For 50-volt lamps.	For 65-volt lamps.	For 80-volt lamps.	For 100-volt lamps.	For 110-volt lamps.
	Ohms.	Ohms.	Ohms.	Ohms.	Ohms.
1	250,000	325,000	400,000	500,000	550,000
10	25,000	32,500	40,000	50,000	55,000
20	12,500	16,250	20,000	25,000	27,500
40	6,250	8,125	10,000	12,500	13,750
50	5,000	6,500	8,000	10,000	11,000
100	2,500	3,250	4,000	5,000	5,500
150	1,666	2,166	2,666	3,333	3,666
200	1,250	1,625	2,000	2,500	2,750
300	833	1,083	1,333	1,666	1,833
400	625	812	1,000	1,250	1,375
500	500	650	800	1,000	1,100
1,000	250	325	400	500	550

* If we include the dynamo as well as the whole of the lamps, motors, etc., will the insulation resistance of the whole installation be half the above figures?

Different Tests.—The ordinary Wheatstone bridge test is the handiest and easiest method of ascertaining the actual resistance in ohms of the conductors as well as of the insulation resistance. Should the insulation, however, be too high for the battery power and the galvanometer, then the direct deflection substitution method may be adopted. These tests are so fully described in every book on testing, and are, besides, so well known, that there is no need to explain them here. The battery power need only be a few Leclanché cells (10 or 12 at the most) if the galvanometer used is of the sensitive-mirror Thomson type.

When the installation has been completed, then the whole of the results may be obtained by means of ordinary ampere and volt meters.

First, join up the circuit as follows, in Fig. 3:

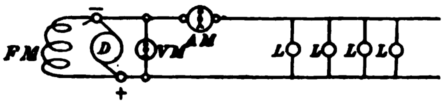

Fig. 3.

Work the installation at its normal power and observe the total current, C, by the ampere-meter, A M, and the difference of potential, E, by the voltmeter, V M. This gives us $\frac{E}{C}$.

Second, join up the voltmeter as in Fig. 4, with one side to earth having previously ascertained its resistance, r, ohms. Also note, C, on the ampere-meter, and see that it is the same as before.

If any leakage to earth exists in the dynamo or in any part of the circuit, a deflection on the voltmeter, V M, will be produced corresponding to the leakage current, c, passing through it, and is represented by, e, volts difference of potential between its terminals,

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Then, $\frac{e}{r} = c$, the total leakage current.

But $\frac{C}{c} = k$, the actual constant or coefficient of the insulation resistance of the system.

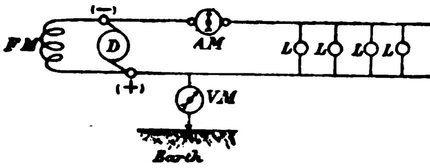

FIG. 4.

Then, if this value is greater than k, our standard constant, the installation may be considered all right as far as insulation resistance is concerned. Of course this does not inform us if any leakage is taking place between the forward and the return system of wires, or between the shunt and the series windings of the dynamo.

To ascertain the former of these, disconnect all the lamps and insert the voltmeter first in the forward lead, and secondly in the return lead, as in Fig. 5, and note if we get any leakage current, c, when the

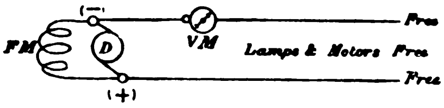

FIG. 5.

dynamo is run at its normal speed. In regard to leakage between the shunt and series windings of the dynamo-magnets, recourse must be had to the Wheatstone bridge test.*

No doubt some of the members will suggest other practical tests, as well as give their experiences of how the insulation resistance of installations with which they happen to be intimately acquainted compare with the various rules herein mentioned, as well as how they stood the test of time—wear and tear of everyday work. What is chiefly wanted is to ascertain the minimum standard of insulation resistance compatible with good honest work and ordinary careful usage.

P.S.—Since correcting the proof-sheets of this paper the writer thought that it might be interesting and instructive if he obtained the insulation resistance of an installation that had been working for some years, because members and others might say that some of the foregoing rules were all very well for *new* work, but were quite inapplicable to *old* work. He accordingly went to-day (January 16, 1889) to Messrs. Graham's large East India offices and warehouses in Cathedral-street, Glasgow, with his testing apparatus, and took careful tests of the insulation resistance of the whole circuit, with the results shown in the following table:

Original date of fitting up installation	1881 82
Date on which most of the wiring was renewed	1883
Date of test (day wet—Glasgow weather)	Jan. 16, 1889
Total number of lamps in circuit of 16 c.p. each	281
E.M.F. at brushes of dynamo, in *volts*	108
Current total from dynamo for all lamps in *amperes* (*about*)	160
Insulation resistance of dynamo-armature and magnet-coils alone, in *ohms*	40,000
Insulation resistance of the *whole* circuit, including the dynamo, *all* leads, switches, cut-outs, and lamps in *ohms*	21,400
Insulation resistance to pass Jamieson's rule, including *dynamo* as well as the *whole* lamp circuit, in *ohms*	19,217
Insulation resistance to pass Society of Telegraph Engineers and Electricians' rule (if their constant includes *dynamo* as well as the *whole* lamp circuit, in *ohms*	3,375

This old installation (the oldest large incandescent light one in Scotland), which has been in full daily working order for over five years (since the wiring was renewed) when tested, without warning or any special preparation, and on a very damp day, gave a better insulation resistance than that demanded by the writer's rule, and over six times that required by the Society of Telegraph Engineers' rule (taking it in its broadest sense).

It is worth mentioning that the president, Sir William Thomson, has taken a special interest in this installation from its very commencement. In 1881, when so few electricians knew practically how incandescent lighting should be carried out, and when the Messrs. Graham were erecting their large new premises, they consulted Sir William Thomson as to whether or not they could reply upon the electric light. Upon his recommendation they fitted their premises throughout with the electric light, without introducing gas-burners into any of their offices and warehouses. The actual carrying out of the present wiring of the building has been entirely done by one of the writer's students, who has had charge of the installation for the last six years. The Messrs. Graham have been so pleased with the care and attention which he displayed that they have sent him to their new premises which they are at present erecting in Oporto, Portugal, to superintend the building and put up an electric light installation there.

The dynamo which the writer tested, and which gave a total insulation resistance of 40,000 ω, against framing and dead earth, is a Manchester shunt-wound machine by Messrs. Mather and Platt, put down about two years ago to replace the direct lighting of the building by three of the oldest shunt-wound dynamos in existence. These three machines are now employed in charging accumulators which serve to feed the lamps used in the darker parts of the building during the daytime. The writer tested the insulation resistance of one of these old machines, and found that it gave for armature and shunt coils just over 10,000 ohms, as against the frame of the machine.

In addition to the above tests, that indicated by Fig. 4 was applied, and no perceptible leakage current was observable on the voltmeter, even although the sensitive coil, which reads to less than a volt, was inserted.

The writer might give the results of several new installations which have surpassed his rule, and which therefore far exceeded the demands of the society's rule. He therefore thinks that the constant of the latter might be raised from 5,000 to 10,000 with perfect fairness, and with beneficial results to the electric lighting industry as a whole.

* For other tests when the installation is at work, see Munro and Jamieson's "Electrical Rules and Tables," 5th edition, pp. 215, 216.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the week ended January 18 amounted to £5,077.

Western and Brazilian Telegraph Company.—The traffic receipts for the past week, after deducting a fifth of the gross earnings payable to the London Platino-Brazilian Telegraph Company, were £4,195.

West India and Panama Telegraph Company.—The receipts of this Company for the half-month ended December 31 were £2,352, against £2,805. The September receipts, estimated at £4,515, realised £4,540. The receipts for the half-month ended January 15 were £2,381, against £2,676.

Cuba Submarine Telegraph Company, Limited.—The Directors of this Company, after providing for the dividend on the preference shares, and placing £4,000 to the reserve fund, recommend a dividend on the ordinary shares at the rate of 9 per cent. per annum, tax free, leaving £1,308 to be carried forward.

Anglo-American Telegraph Company, Limited.—This Company recommend a balance dividend of 15s. per cent. on the ordinary and one of 30s. per cent. on the preferred stock for the year ending the 31st of December, both payable on the 2nd of February, less income tax, to the stockholders registered on the 14th inst. After paying the foregoing, there will be an estimated balance of £1,325 to be carried forward. The above dividends together with those already paid will amount to £1. 12s. 6d. per cent. on the ordinary and £3. 5s. per cent. on the preferred stock for the year 1888.

Eastern Telegraph Company, Limited.—The report of this Company for the half-year ended September 30 states that the revenue amounted to £310,104, from which are deducted £83,332 for the ordinary expenses and £43,075 for expenditure relating to repairs and renewals of cables, etc., during the half-year. After providing for income tax there remains a balance which, added to £884 brought forward, makes a total of £180,355. Interest on debentures and debenture stock took £28,264, the dividend on preference shares £20,474, and two interim dividends of 1¼ per cent. each on the ordinary shares £95,000, £36,616 being carried forward.

Direct United States Cable Company, Limited.—This Company in their report for the six months ended December 31, state that the revenue (still subject to revision on settlement with the French Company), after deducting out-payments, amounted to £34,188, against £23,003 (after similar deductions) for the corresponding period of 1887, the difference of £11,185 in favour of the half-year under review being due to the increased tariff in force since the 1st of September. The working and other expenses for the same period, including income tax, amounted to £16,475, leaving a balance of £17,712 as the net profit. Interim dividends of 2s. for the quarter ended September 30, and of 3s. 6d. for the quarter ended December 31, together amounting to £16,695, have been declared. The tariff was on the 1st of September raised to 1s. per word, by agreement between the associated companies (including the French Company) and the Commercial Cable Company. The result of the altered rates so far has been to reduce the volume of the traffic, but the receipts have, it is stated, been fully augmented.

Bell's Asbestos Company, Limited.—The report of the Directors for the year ended 31st December, to be presented to the shareholders at the first ordinary general meeting to be held at Cannon-street Hotel, on Wednesday next, states that the net profit from the ordinary trading of the Company after making all needful deductions, including depreciation of machinery and bad debts, amounted to £23,429. 6s. 5d., and the net profit from the Company's Asbestos Estates in Canada to £10,992. 0s. 4d.; a total of £34,421. 6s. 9d. From this the Directors write off the whole of the preliminary expenses account amounting to £836. 14s. 7d., and under the terms of the articles of association they place to reserve fund, £5,000; a total of £5,836. 14s. 7d., leaving for appropriation, £28,584. 12s. 2d. Out of this, the Directors recommend the payment on the 4th February proximo of a dividend of 15s. per share, free of income tax, which, with the interim dividend paid in July last, makes a total distribution of 22½ per cent. for the year, and the payment of the bonus, £2,250, to the Managing Director and Directors, in terms of the articles of association, carrying forward a balance of £3,834. 12s. 2d.

German Union Telegraph and Trust Company.—An extraordinary general meeting of the German Union Telegraph and Trust

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Company, Limited, was held on Tuesday, the 22nd inst., at Winchester-house, Old Broad-street, Sir James Anderson in the chair, to consider special resolutions requiring the Company to be wound up voluntarily and appointing liquidators (in accordance with the arrangements under which the Imperial German Government would take over the cables and property of the German Union Telegraph Company of Berlin). The Chairman stated that the first payment made by the liquidators of the Berlin Company would enable the liquidators of this Company to return to the shareholders about £7. 7s. 6d. per £10 share. They expected to be able to make their first payment in the first week of February; and they hoped to complete the winding up of the Company and to make a final payment to the shareholders early in May. They hoped to be able to make a total return to the shareholders of very nearly par. He concluded by moving a resolution authorising the winding up of the Company. Mr. H. G. Erichsen seconded the motion, which was adopted; and a further resolution was afterwards passed appointing Sir James Anderson and Mr. William Payton liquidators of the Company. In answer to a question, the Chairman added that the cable was now being worked by the German Company.

NEW COMPANIES REGISTERED.

Miners' Lamp Electric Lighting Company, Limited.—Registered by Waterlow Brothers and Layton, Limited, 24 Birchin-lane, London, E.C. Capital £3,000, divided into 600 shares of £5 each. Object: to purchase or otherwise acquire a certain invention and letters patent for lighting miners' safety lamps and wicks, and to carry on the business of a safety lamp manufacturing company and electric light company in all its branches.

Maxim-Weston Electric Company, Limited. — Registered by Gresham and Davis, 12, Old Jewry, London, E.C. Capital £75,000, divided into 500,000 shares of 3s. each. Object: to acquire and undertake the property and liabilities of the Maxim-Weston Electric Company, Limited (in liquidation); to light streets, thoroughfares, public places, public or private buildings, manufactories, mines, houses, ships, etc. The first subscribers are:

	Shares.
A. Cousens, 28, Westbourne-park-villas	1
J. R. McVeagh, 1, Upper High Lever-road, W.	1
W. H. White, Stock Exchange, E.C.	1
G. H. Hildyard, Great Dover-street, Borough, S.E.	1
J. G. Couchman, Southwood, Eltham-road, Lee	1
A. R. Ramsay, 2 Metal Exchange-buildings, London, E.C.	1
B. Whitworth, jun., 2, Metal Exchange-buildings, London, E.C.	1

The first Directors shall be John Marks, 113, Great Russell-street, W.C.; James Gunton Couchman, Southwood, Eltham-road, Lee; George Herbert Hildyard, 34, Wickham-road, St. John's, S.E.; John Matthew Klenck, 42, Bishopsgate-street, E.C.; and Louis Swaby, 23, Churchfield-road, Ealing. Each Director shall hold at least 250 shares in the capital of the Company. The remuneration to the Directors shall be the sum of £1,100 per annum, to be divided amongst them as they may determine.

Newcastle and District Electric Lighting Company, Limited. Registered by E. Flux and Leadbitter, 144, Leadenhall-street, London, E.C. Capital £50,000, divided into 5,000 shares of £10 each. Object: to act as undertakers for the supply of electricity for lighting and other purposes, whether public or private, in the city of Newcastle-upon-Tyne or anywhere else in the United Kingdom, and to do all or any such acts as may be necessary to promote, support and sustain any Acts, provisional orders, licenses or other authorities which may be required or be deemed necessary to benefit the Company, or for the more properly carrying out of all or any of the objects of the Company. The first subscribers are:

	Shares.
The Hon. C. A. Parsons, Elveston Hall, Ryton-on-Tyne	1
Sir B. C. Browne, West Acres, Newcastle	1
J. D. Millbourn, West Jesmond House, Newcastle	1
J. B. Simpson, Hedgefield House, Ryton-on-Tyne	1
H. C. Harvey, St. John's Chambers, Newcastle-upon-Tyne	1
Rt. Hon. Earl Crawford, 2, Cavendish-square, London, W.	1
A. F. Wade, 9, Albert-mansions, Victoria-street, London, S.W.	1
W. M. Angus, St. John's Works, Newcastle-upon-Tyne	1
C. W. Spencer, Mewburn Steel Works, Newcastle-upon-Tyne	1

Registered without articles of association, and therefore the clauses of the first schedule of the Companies Act, 1862, will apply.

PROVISIONAL PATENTS, 1889.

JANUARY 14.

656. **Measuring the quantity of a direct or alternating current of electricity.** William Henry Dines and Leonard Wilson Gatward, Bancroft, Hitchin.

706. **Electric accumulators.** Michael Radcliffe Ward, 9, Warwick-street, Regent-street, London, W.

JANUARY 15.

731. **Improvements in conduits for cable and electric railways.** William John Brewer, 33, Broadway, New York, U.S.A.

733. **Improvements in apparatus for controlling the speed of engines employed for driving dynamos, so as to ensure steady and equable lights.** Richard Wilby, Commercial-street, Halifax.

746. **Improvements in and relating to electric secondary batteries or accumulators.** Orazio Lugo, 45, Southampton-buildings, London, W.C. (Complete specification.)

757. **Improvements in and relating to a system of suspended bare wires, travelling connections between the said wires and the motor and switches, &c., in and for electric railways.** Charles Joseph Van Depoele, 77, Chancery-lane, London, W.C. (Complete specification.) (Date applied for under Section 103 of the Patents, &c., Act, 1883, 9th August, 1888, being date of application in the United States.)

759. **Improvements in switches for electric railways.** Clark Homer Wells, 77, Chancery-lane, London, W.C. (Complete specification.)

JANUARY 16.

811. **Improvements in the mode of application of magnetism and electricity for medical purposes.** John Garton, Willow Bank, Newton-le-Willows, Lancashire.

813. **Separation of aluminium and its alloys from its fluorides by electric or by chemical metallurgic process.** Wilhelm Diehl, 89, Chancery-lane, London, W.C.

JANUARY 17.

859. **Improvements in telephonic apparatus.** Herbert Feilden Jackson and Daniel Sinclair, 62, St. Vincent-street, Glasgow.

877. **A magnetic and sight compass.** Willoughby Verner, Charles-street, London, S.W.

895. **An improvement in or connected with electrical connections for burglar alarms.** John Crisp Fuller and George Fuller, 33, Chancery-lane, London.

898. **Combined fire-alarm and telephone telegraph.** George C. Hale, Albert Barrett, and Joseph Zeutner, 45, Southampton-buildings, London. (Complete specification.) (Date applied for under Section 103 of the Patents, &c., Act, 1883, 27th June, 1888, being date of application in the United States.)

915. **Improvements in electric switches.** Sebastian Ziani de Ferranti, 45, Southampton-buildings, London, W.C.

JANUARY 19.

983. **Improved electric time alarm and indicator.** C. Adams-Randall, 15, Montpelier-square, Brompton, London.

997. **Improvements in secondary or storage batteries.** Thomas Cuttriss, 72, New Briggate, Leeds.

1,006. **Improvements in electrical pole-changers.** Percy Coote, 40, Preston-road, Brighton.

1,018. **An improved method and apparatus for facilitating the working of telegraph instruments.** George Edward Adler, 98, North End, Croydon, Surrey, S.E.

1,031. **Improvements in dynamo-electric machines.** John Wm. King, 13, St. John's-square, Clerkenwell, London, E.C.

1,038. **Improvements in and relating to electric lamps for signalling purposes.** John Price Rees, 45, Southampton-buildings, London.

1,047. **Improvements in propelling vehicles by means of electric motors.** Michael Radcliffe Ward, 24, Southampton-buildings, London, W.C.

SPECIFICATIONS PUBLISHED.

1887.

17,902. **Telephone exchanges.** Pitt. (Scribner.) 11d.

1888.

56. **Incandescence electric lamps.** Johnsön. (Mace.) 6d.

531. **Generating, &c., electricity.** Edmunds. 11d.

2,525. **Arc electric lamps.** Richardson. 8d.

2,586. **Incandescent electric lamps.** Kennedy. 8d.

2,784. **Electrically lighting railway carriages.** Imray. (Imray.) 8d.

2,785. **Electric glow lamps.** Lauckert. 8d.

2,794. **Electrical firing keys.** McEvoy. 8d.

8,700. **Electric batteries.** Renard. 8d.

11,941. **Non-magnetic metallic alloy.** Ostermann and Lacroix. 4d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday.
12 Feb.	1/2	Anglo-American Brush E.L.	4	4¼
12 Feb.	2/0	— fully paid	5	5¼
14 Nov.	0/4½	Con Telephone & Main	1	[illegible]
27 July	10/0	India Rubber, G. P. & Tel.	10	19
16 Mar.	5%	Maxim Weston	1	[illegible]
30 May	2½%	Oriental Telephone	11	[illegible]
26 April	4/0	Reuter's	8	7½
......	...	Swan United	8½	2¼
12 July	12/0	Telegraph Construction	12	41½
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	13

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NOTES.

Kiel.—The establishment of a central station for Kiel is now being discussed, to start at first with 500 incandescent lamps.

Southwark.—St. Saviour's, Southwark, offers no opposition to electric lighting schemes, but insists that all wires should be laid underground.

A New Electrical Journal.—The *Gas World* is becoming more and more electrical: about seven columns out of thirty-two are devoted to our subjects.

Wallsend.—The Wallsend Local Board consider themselves treated contemptuously by the gas company. They are considering the question of electric lighting.

The Whitehall Installation.—The battery of accumulators are now down at the Whitehall central station. The Hotel Metropole and the Grand Hotel, Charing Cross, are both to be connected to this station.

Holborn.—At the last meeting of the Holborn Vestry, a meeting was called to be held on Monday, February 18, to consider the applications of the London Electric Supply Corporation and the Metropolitan Electric Supply Company.

Electrical Tree Cutter.—Messrs. Ganz and Co. have constructed an electrical tree cutter for use in the forests of Galicia. This consists of a drill driven by electricity, by means of which a series of holes close together can be made through the trunk.

Metropolitan Company's Stations.—The new Sardinia-street central station—Westinghouse system, 25,000 lights—is to be ready in March. The Waterloo Bridge station—Kapp system, by Messrs. Johnson and Phillips—is to be ready about next June or July.

Electric Sugar.—It has been said that Friend, the inventor of electric sugar, is probably still alive, and ready to commit further frauds with the proceeds of this one. There need be no fear. Dr. Crosby, who attended his last illness, certifies to his having drunk himself to death some time ago.

Lighting of the Hotel de Ville.—On the eve of the Paris election, M. Jacques, who was the opponent to Boulanger, was entertained at a public ball at the Hotel de Ville, Paris, when 12,000 guests were present, and the whole suite of rooms was splendidly lighted up by electricity for the first time.

A New Use for the Compound Wire.—A French writer in *Cosmos* points out that in a compound-wound dynamo the machine can be used as a shunt or series dynamo only, and induced currents can be obtained from the disconnected wire; these "parasitical currents," he suggests, "might be used for lighting another circuit of lamps, or other purposes."

Court Theatre.—A gauge glass blew out the other night at the Court Theatre installation. No one knew what to do; the place was full of blinding steam, everyone flew, the cut-outs went, the engines raced, Messrs. Sharp and Kent were at their wits' end, when a young engineer happening to pass, seeing the steam and their sad plight, drew their fires for them and prevented a catastrophe.

A Meeting of Vestries.—The Wandsworth Board of Works has invited a meeting of delegates to secure combined action on the part of the local authorities of London with regard to electric lighting. We should certainly believe in some combined action of this kind, as to the interests of both parties, but should like delegates from the Electrical Section of the Chamber of Commerce also to be invited.

Electricity in Mines.—The Belgian Government have recently appointed a commission to enquire into the use of electricity in mines, and to settle upon regulations to be imposed in such cases for proper security of life. Blasting, lighting, transport, haulage, etc., will all occupy the attention of the commission, and it is hoped that the result of their experiments and deliberations will be to considerably extend the use of electricity in mining.

Board of Trade Unit.—The new Board of Trade unit suggested by the Electrical Section of the London Chamber of Commerce to be 10 times that of the old Board of Trade unit, has been definitely adopted by the Board of Trade. It is now, therefore, 10,000 watt-hours instead of 1,000 watt-hours as heretofore. The new unit is far more applicable commercially, and in view of this change we publish this week a comparison of the cost of lighting at various prices per new unit with that of gas per 1,000 cubic feet. This should prove useful to town councils and other authorities and firms intending to adopt the electric light and desiring to ascertain the comparative cost at any specified price per unit.

Prevention of Smoke.—The smoke nuisance is a point that central stations, comprising thousands of horsepower, in the centre of towns will have great difficulty with. A way of salvation for the gas companies has been pointed out in a paper on the prevention of smoke from boiler furnaces, lately read at the Institution of Engineers of Scotland. Methods adopted were described by Mr. Geo. C. Thomson, F.C.S., and particulars were given of the immense amount of sulphuric acid sent into the air, and loss occasioned in fuel, and damage to the parks, trees, houses, and vegetation. The proper way, Mr. Thomson suggested, was to convert the coal into gas first, distilling the sulphur, which would pay for the cost of gas making.

Dublin Central Lighting.—At a specially-convened meeting of the Dublin Municipal Council, held on Monday, it was all but unanimously resolved, there being only one dissentient, "to apply to the Board of Trade for a license to supply electric lighting for private purposes." It will be in the recollection of our readers that the Dublin Corporation have already acquired a license for public lighting, but on consideration it was found that the inducements to contractors would, of course, be much greater when private as well as public lighting could be undertaken. The Council have therefore very rightly decided to have their license amended, and it is hoped, before many months go by, active preparations will be on foot for the lighting by electricity of some of the principal streets of Dublin.

Business in Dublin.—The Dublin Alliance Gas Company have put down a new electric light installation during the past year, and are at present lighting some of the large business houses with both arcs and incandescents, and are offering inducements to new customers. There are also several other isolated installations working satisfactorily, such as those at Messrs. Guinness's Brewery Messrs. Findlaters, Mr. Talbot Powers, etc. Perhaps the most complete and successful installation at present working in Dublin is that at the offices of the *Irish Times*, which was erected about five years ago, and has been running

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continuously ever since, under the superintendence of Messrs. J. K. Fahie and Son, electrical engineers, of Dublin.

Islington.—The Special Committee appointed to consider the applications of the London Electric Supply Corporation and the Metropolitan Supply Company, asking for the Vestry's assent to their applications for provisional orders, recommended that the clerk be directed to lodge objections to such provisional orders with the Board of Trade, in order to secure a *locus standi.* Mr. Price, who moved the adoption of the report, said that it was the unanimous wish of the committee that electric lighting should be brought into the parish if possible, but it was necessary that the Vestry should have a *locus standi* when the applications of the companies came before the Board of Trade. Mr. Friend seconded the adoption of the report, which was carried.

Electric Light and the Eyes.—The question as to whether those who have to do with powerful electric lights suffer in eyesight is discussed by Dr. G. M. Gould, of Philadelphia, who has written an interesting paper entitled "Is the Electric Light Injurious to the Eyes?" He concludes that the "light of the future" has not been proved to be injurious except in the case of those "who approached it very closely, gazed at it protractedly, and without protecting coloured spectacles." There is no justification for the popular prejudice against the use of the diffused light as an illuminant. The ocular injury occasionally incurred, due to the greater number of light waves, is characterised by temporary retinal paralysis, by blepharospasm, central scotomata, chromatopsia, etc., and is marked by intense photophobia, lacrymation, conjunctival congestion, etc. The attack usually lasts two or three days, the treatment being cocaine and atropine, and cold or hot compresses.

Another House-to-House Station.—The St. Martin's-in-the-Fields Vestry held a special meeting on January 24, to consider a motion to give consent under Rule 8 of the rules made by the Board of Trade with respect to applications for licenses and provisional orders under the Electric Lighting Acts 1882 and 1888, to the granting of a license by the Board of Trade, authorising the House-to-House Electric Supply Company, Limited, to erect, construct, and maintain a central station for electric lighting, with lines and works necessary to the same, and to supply electricity within the parish. The chairman thought that the Vestry should make up its mind how far they should go with respect to these companies. The Vestry had given consent to the application of two companies. The clerk said the Board of Trade were not disposed to grant licenses for large areas. Mr. Scott asked if the companies would be rated, and the clerk said they would. Mr. Wakefield moved that consent be not given, as he considered the information not sufficient. Mr. Prescott moved that consent be given, which was seconded, and carried.

Liverpool.—On Tuesday a deputation, representing the Liverpool Electric Supply Company, waited upon the Watch Committee of the City Council, and endeavoured to procure their assent to the provisional order which the company intend to seek during the forthcoming session of Parliament. The order, if obtained, will confer extended powers upon the company in the direction of lighting the streets of Liverpool by means of electricity, and it is of importance to the company that the Watch Committee should give their assent to the application which they propose to make to Parliament. This consent has hitherto been withheld, as the Watch Committee have failed to induce the company to agree to conditions which are deemed to be essential in the interests of the public. The object of yesterday's interview was to endeavour to arrange terms which might be mutually satisfactory; but we understand (says the *Liverpool Courier*) that, in spite of an unusually protracted consultation, it was found impossible to come to terms, and the practical result, therefore, is that the Watch Committee will refuse their assent to the company's application.

The Man with the Iron Pipe.—We do not wish in any way to liken Mr. Lowrie to disreputable personages, but the details which he has worked out of the House-to-House scheme remind us of the tale at the battle of Trafalgar-square. A man in that struggle of the unemployed was seen with apparently an innocent roll of paper in his hand, when it was noticed that he was dealing death and destruction around. What appeared to be simply paper was speedily found to be a piece of iron gas pipe pasted over with paper, and then the man with the iron pipe was found to be a formidable enemy. We think that the details of the underground boxes and iron piping for the electric distributing wires at West Brompton will carry more terror into the camp of the gas men than any other detail. We may prate of amperes and volts, and even talk of candle-power and so many thousands of incandescent lamps: these may be understood—more or less—and combatted in their own minds. But when it comes to iron pipes laid along streets, that is a point the gas world *can* understand and appreciate; and it does not need much imagination of electricity or lines of force to conceive of an extension of electric lighting by copper wires when iron pipes can be laid and connected up in all directions. Then, here's health to the man with the iron pipe!

Berly's Universal Electrical Directory.—We have received the 1889 edition of this well-known directory, and perhaps the best way to show its value and importance will be to describe its contents. In the first instance, we have a fairly complete list of modern books on electrical subjects, followed by a table relating to the new legal standard wire gauge. The principal part of the book comes next, and consists of an alphabetical list of persons engaged in the electrical and cognate industries, after which we have a list of the members of the Institution of Electrical Engineers, and of the Electrical Section of the London Chamber of Commerce. The British classified trades come next, and takes up a space of over one hundred and twenty pages. Further on we have the alphabetical and classified trades' sections devoted to American and continental electrical engineers. The extent of the whole work will be understood when we say it reaches to nearly four hundred and fifty pages. The great value of a directory depends upon its completeness and correctness, though absolute correctness is an impossibility. Upon this matter we cannot as yet speak from experience, though we hope to be able to do shortly. Meanwhile, we are assured that great efforts have been made to obtain accuracy, and when inaccuracies occur it is frequently the fault of the people themselves, who will not answer repeated enquiries. So far, however, as we can test from a cursory examination, the work is fairly accurate and complete.

Strand District.—At the meeting of the Strand Vestry, on Tuesday, Mr. Sinden moved the adoption of a report from the Roads Committee, recommending that this Vestry dissent from the granting of a provisional order by

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the Board of Trade to the London Electric Supply Corporation, Limited, for the supply of electricity in this parish, under the Electric Lighting Acts; that this Vestry assent to the granting of a license by the Board of Trade to the House-to-House Electric Lighting Company, Limited, authorising that company to supply electricity within this parish. In answer to questions, Mr. Sinden said the committee objected to the first application because a provisional order would give the company privileges in the parish for forty-two years. The second company asked for a license which would only extend over seven years. A long discussion ensued, in the course of which Mr. Layman moved, as an amendment, that the matter be adjourned until the next meeting of the Vestry. This proposition having been negatived, Mr. Bacon moved a further amendment, suggesting a postponement of the matter, but the chairman declined to take any more motions for adjournment. Mr. Bacon: Then all I have to say is that you don't know your business as chairman. The first recommendation was adopted, but the consideration of the second recommendation was deferred until the next meeting of the Vestry, in order that the representatives of the House-to-House Company might be in attendance.

Amalgamated Zincs.—We have received from Mr. J. Beattie, jun., information relating to tests made by the electrician of one of the supply companies in Chicago, which reads as follows: "In 16 tests for E.M.F. four were made on a sal-ammoniac solution, six on a copper zincic sulphate solution, and six on a bichromate solution. Half of the tests were made with the ordinary commercial zincs and the other half being with the Beattie zinc. In the sal-ammoniac solution there was a rise of 2 per cent. in the E.M.F., in the sulphate solution a rise of $1\frac{8}{10}$ per cent., and in the bichromate a rise of $2\frac{2}{10}$ per cent. in E.M.F., showing that the Beattie zinc had an average of 2 per cent. the advantage of ordinary commercial zinc in point of E.M.F." As regards internal resistance, he says: "With the sal-ammoniac solution the internal resistance was reduced 22 per cent.; with the sulphate solution the internal resistance was reduced 32 per cent., 40 per cent. and $41\frac{1}{2}$ per cent.; in bichromate solution the internal resistance was reduced 11 per cent. . . . With a given amount of work done upon the outside circuit of the battery, as nearly as I could test, there was an average of 18 per cent. less zinc consumed by weight, and I should judge also that the care of the battery with this zinc would be much less. Short-circuiting was tried with the sal-ammoniac solution only, and shows satisfactory results owing to the fact that crystals do not form and the solution will recuperate somewhat more rapidly with these zincs than with the commercial zinc." This amalgamated zinc differs from the ordinary zinc in that, according to Mr. Beattie, it is amalgamated throughout its whole body, and not merely on its surface. Mr. Beattie also claims to have discovered a better carbon for battery work. It is made from salt hay and salt meadow grass. This is carbonised, pulverised, and moulded as required, and it is claimed has greater conductivity than the ordinary gas rebut carbon.

Storage Battery Patents.—As we gave the information relating to the Julien Company's patents, it is but just we should give the following from the Electrical Accumulator Company, Limited: "A public statement from the Julien Company has appeared, which it is made to appear that the application of the Electrical Accumulator Company for a certain patent has been refused by the United States Patent Office. Such a statement is not true; on the contrary, the Commissioner of Patents, Washington, has just rendered a decision sustaining the claims of John S. Sellon as the inventor of an inoxidisable alloy support plate, and Mr. Sellon's patent has been passed to issue, and will shortly appear on the patent records duly assigned to the Electrical Accumulator Company. The application of Sellon was founded upon the specification of his English patent No. 3,987, dated September 15th, 1881. This British patent of Sellon's is the first publication to describe the use of a plate of lead and antimony, or an alloy of two metals, either with or without the use and application of an amalgam as a support for the active material in a battery of the Faure type. Immediately following the decision of the commissioner above referred to, a second application of Sellon's claiming an alloy of two or more metals and an amalgam, was placed in interference with Julien's patent. It will thus be seen that litigation up to this date in the Patent Office has resulted in the substitution of Sellon's second application for the first application which was placed in interference on the allowance or passing of Sellon's first application to issue. The issue of this patent in the United States will enable the assignee of Sellon, the Electrical Accumulator Company, to control the manufacture, use and sale of secondary batteries employing lead and antimony in the composition of the support plates, whether mercury to form an amalgam be present or not, and suits will be instituted in the courts for the recovery of damages at once."

St. George's, Hanover-square.—At a meeting of the St. George's, Hanover-square, Vestry on Thursday, January 24, Mr. H. H. Seymour presiding, the Electric Lighting Committee submitted a long report, which showed that the following companies were applying for provisional orders to supply the parish with the electric light: The London Electric Supply Corporation, Limited; Metropolitan Electric Supply Company, Limited; Westminster Electric Supply Company, Limited; and the Chelsea Electric Supply Company, Limited. The report recommended that the application of the latter company should be refused, and, if necessary, opposed before the Board of Trade; that the matter be referred back to the committee for negotiation with the three other companies with a view to altering their drafts in certain particulars; and that the Vestry authorise the committee to instruct Messrs. Caprons and Co., solicitors, to oppose all or any of the four schemes, as might appear expedient. The suggested alterations included binding the companies to complete any works within eighteen months from the date of the order instead of two years; that, providing a company fail to perform its obligations to light any place, a money penalty should be inflicted rather than a revocation of its order as to that particular place; that the quality of the lighting should be subject to the inspection and superintendence of the County Council, and that deposits of £500 should be made to answer damages by work which might be begun and never continued. Such a deposit the committee would not ask for in the case of the London Electric Supply Corporation, because it had valuable work in that parish and elsewhere, and was thoroughly responsible. The Metropolitan and Westminster companies were not in any such position, and it was thought prudent to require a deposit from them. The adoption of the report and recommendations was moved by Lord Hobhouse, seconded by Sir William Farrer, and agreed to unanimously. The committee sat for about three months on this subject,

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Gilchrist Science Lectures.—A lecture, under the auspices of the Mayor and Corporation of Norwich, illustrated by the oxy-hydrogen light and numerous experiments, was delivered in St. Andrew's Hall, Norwich, last Monday, to an extremely crowded audience, on "The Position and Prospects of Electric Lighting," by Mr. W. Lant Carpenter. The syllabus of the lecture was as follows: Meaning of the term Electric Current; Methods of producing it for lighting purposes, (*a*) by "Primary Batteries," *i.e.*, by chemical action, (*b*) by dynamo machines, which, by converting Mechanical into Electrical Energy, produce Electricity at the least possible cost; Explanation of the principle of the Dynamo, and of some of its chief types; its great perfection as a machine, compared, for example, with the Steam-engine; Secondary (or storage) batteries or accumulators, their theory and construction; in any system of Gas Lighting, production, storage, distribution, and consumption have to be considered; the same is the case with Electric Lighting; Modes of distributing currents at high and low Electric pressure; their relative advantages, etc.; Continuous and alternating currents; Transformers for changing currents distributed at high potential to those of low potential suitable for use, and free from danger; Electric Meters; Source of the light in Electric lamps; the transformation of Electrical energy into heat energy, owing to the resistance opposed to the passage of the current; Arc and incandescent (or glow) lamps—the uses for which each is best adapted; the light being produced without combustion, but little heat, and no noxious products are formed; Comparison of cost between Electric and other methods of lighting; Present position of the industry in England, the Continent, and America; Central station lighting; Private installations; Ship lighting, especially in the Suez Canal; Theatre lighting; Electric light in coal mines, powder magazines, etc.; Effect of recent judicial decisions, and of legislation upon the industry; Conclusion. The lecturer was assisted in the experiments by Messrs. Laurence, Paris, and Scott, electrical engineers, of Norwich. The same lecture will be delivered this week, for the Gilchrist Trust, in Hinckley, Wolverhampton, Wrexham, and Burslem.

Trial of an Electric Car Brake.—The Widdifield and Bowman electric car brake, says the *Scientific American*, was subjected to a series of tests on January 10, a train of fifteen freight cars being used for the trial, which took place upon the Lehigh Valley Railroad between Metuchen and Easton. A drum about six inches in diameter is cast around the axle of a pair of car-wheels. The drum is composed of Babbitt metal, with paper discs embedded in it. A small friction-wheel is drawn against this by the action of a magnet excited by the electric current. Only an instant is required to do this, as a ratchet bar and pawl are provided to hold the wheel in place when forced against the friction-drum. At once the wheel begins to rotate, and in doing so winds a chain around its axle. This draws a larger wheel, with, of course, greatly increased power against the friction-drum. It rotates, and winds the brake chain directly around its axle, thus putting on the brake. To release the brakes, another current is sent, which operates a second magnet that unlocks the pawl and ratchet, the friction wheels fall back, and the brakes cease to act upon the periphery of the wheel. Two storage batteries of 10 or 12 cells each are carried, one on the engine and the other in the rear car. With each battery is a switchboard and connections. Thus, if the train breaks in the middle, each half is provided with a full brake equipment. An automatic attachment is so arranged that if the train is cut in two by design or accident, the brakes are at once put on. But each switchboard contains a releasing switch, so that if the cut-off occurs in a place where stoppage would be dangerous, the brakes can be released on either or both portions of the train. Attachments are also provided so that brakes can be put on from the roof. The main battery is kept on open circuit, and is only closed for an instant, when the brakes are to be actuated. One or two cells are kept on closed circuit to operate the automatic part. Thus, there is a very slight waste of electricity. In all the trials, which included emergency and service stops, cutting off portions of the train, etc., the mechanism worked perfectly, and it seemed well adapted for its ends. Its cost was stated to be but a small fraction of that of an air-brake equipment. The trials were witnessed by a number of representative railroad engineers and journalists.

Electric Traction on the Metropolitan.—At the meeting of the Metropolitan Railway Company the directors refer in their report to the proposed working of their railway trains by electricity. They regret that the Electric Traction Company have not yet been able to complete their arrangements for the experimental working by an electric power locomotive on a section of their railway. The following letter from the chairman of the Traction Company has been received: "The Electric Traction Company, Limited, New Broad-street House, London, E.C., 31st December, 1888: The Board of Directors, Metropolitan Railway, Gentlemen,—In reply to your enquiry respecting the progress of the electric locomotive for your company, I have to say that the difficulties which were spoken of in your last report, which principally concerned the working of the vacuum brake without the use of steam, though intractable for a considerable time, have now been overcome. The whole matter is in active progress, and has made considerable advance since the last report. The Electric Traction Company wish it to be explained that an erroneous belief appears to be entertained that they propose to suggest traction by means of accumulators for ultimate use on the Metropolitan line. This is not the case. The use of accumulators is for a temporary service only, and is rendered necessary by circumstances connected with the traffic, which will disappear when electric traction is adopted on the Underground Railway.—I am, gentlemen, yours faithfully, (signed) Bury, chairman, Electric Traction Company." The brake difficulty was a very practical one. The working of the vacuum brake without steam, can, of course, be accomplished when sufficient attention to the mechanical details has been given. We might suggest a more radical course—the entire abandonment of air brakes for electrical brakes. The question of electrical brakes has been before us for some time, but no practical tests have been forthcoming. We are fortunately able, however, at this very moment to refer to practical tests of an electrical air brake, which will be found in another note, and we invite the attention of Lord Bury and the directors of the Metropolitan to this new departure, which may prove extremely important, especially when electric locomotives are adopted. The whole of the travelling public of London is anxiously awaiting the result of the trials of electric locomotives on the Underground Railway, and they will bless the day when electrical and railway engineering combine to add so largely to their comfort.

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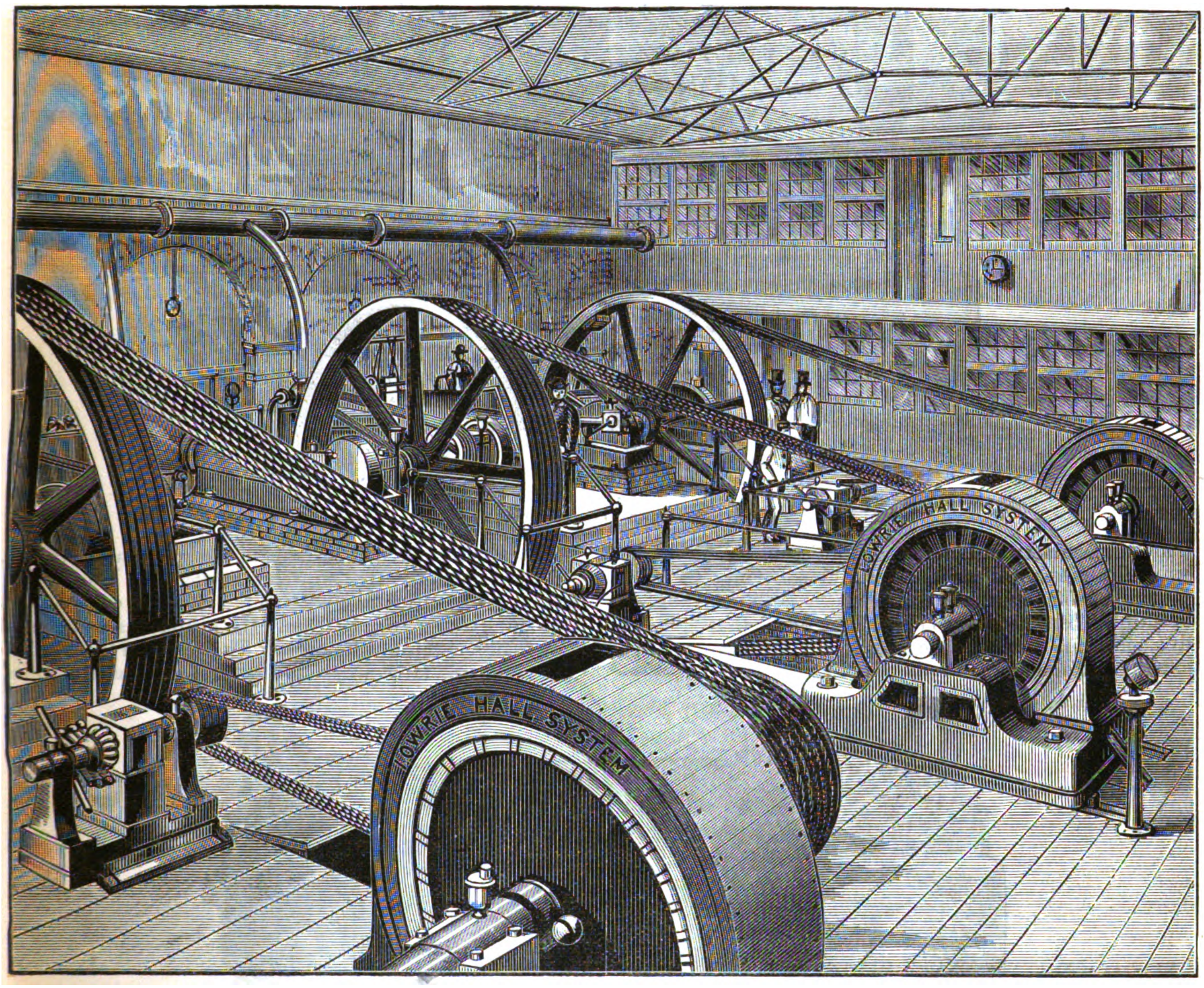
THE HOUSE-TO-HOUSE COMPANY'S STATION AT WEST BROMPTON.

On Thursday week the new central electric light station of the House-to-House Electric Supply Company, Limited, at West Brompton was thrown open for inspection. The inauguration of the station was made the occasion of a very active state of jubilation, explanation, and festivity, and a large number of influential persons attended to inspect and admire the machinery and hear the explanations of Mr. Robert Hammond, the managing director of the company, and of Mr. Lowrie and Mr. Hall, the engineers under whom the station has been carried out. The guests were afterwards entertained at a dinner at Bailey's Hotel. Among those who visited the station were the Earl of Dunraven, P. Grenfell, Killingworth Hedges, C. A. Mocatta, C. G. Mott, F. de Murietta, B. Newgass, C. Nursey, Dillwyn Parrish, W. H. Peto, Theodore Pim, H. L. Raphael, George Richardson, D. Trail Robertson, George Rose-Innes, E. C. Sandeman, W. Booth Scott, C.E., B. Verity, and, of course, the representatives of the technical press.



View of the House-to-House Company's Dynamo Room at the West Brompton Station.

Earl Russell, Sir J. H. Puleston, M.P., Sir Owen Roberts, Sir Tindal Robertson, M.P., Sir Henry Roscoe, M.P., F. Wootton Isaacson, Esq., M.P., H. Seton-Karr, Esq., M.P., Samuel Montague, Esq., M.P., Henry Kimber, Esq., M.P., Hyde Clarke, Esq., F.R.S., W. H. Preece, Esq., F.R.S., Prof. Wm. Henry, F.R.S., Prof. George Forbes, F.R.S., Prof. Silvanus P. Thompson, D.Sc., Prof. W. G. Adams, F.R.S., Prof. Flower, F.R.S., Major-General Vatchell, Colonel R. T. Armstrong, Colonel Fitz-George, Colonel E. P. Meadows, Captain Cardew, Captain Morris, the Mayors of Brighton, Portsmouth, and Folkestone, Mr. Alderman H. Davey, of Brighton, Mr. Alderman G. Manwaring, of Hove, Mr. Alderman E. Martin, of Brighton, Mr. Alderman G. H. Soper, of Brighton, Messrs. J. Keith Angus, J. Spencer Balfour, J. W. Batten, A. Cassella, W. Lant Carpenter, J. C. Cohen, John Collinson, J. Crookes, F. Dethridge, Leon Drugman, R. W. Eddison, R. E. Farrant, W. G. Fossick, R. H. Fowler, A. C. Lorraine Fuller, Percy C. Gilchrist, J. E. H. Gordon, David Greig,

Description of the Station.

The site of the electric light station consists of a long strip of land 470ft. long by 60ft. wide, immediately adjoining the West Brompton railway station. The plan of the buildings is given in the accompanying illustration, which clearly shows, to scale, the position of the machinery, the portion of the site which is left dotted being reserved for extension of the system. On going down the inclined cartway one sees the offices and shops at the right hand. These are hardly yet finished, and the scaffolding is still up. Over the last of these buildings is an immense water-tank for supply of the boilers, fitted with its indicator. At the bottom of the cartway the station proper begins, and this is closed in by an immense corrugated iron partition. Inside this is the first boiler-house, further boilers being able to be added in the vacant space nearer the entrance. The boiler-house at present constructed presents a very handsome appearance, from the engineer's point of view, and is very conveniently arranged. High stacks of cast-iron framing enclose the six boilers, which are of the latest Babcock and Wilcox type. Further along are two Worthington pumps for pumping feed water into the boilers. Feed heaters are arranged on the inlet pipe, by which the waste heat of the exhaust is utilised, but no attempt is made to save the heat of the products of combustion going into the chimney-shaft A sump-pit has been dug near the boilers, into which the escape water drains, and into this the blow-off is led and condenses into seven feet of water, any escaping steam being

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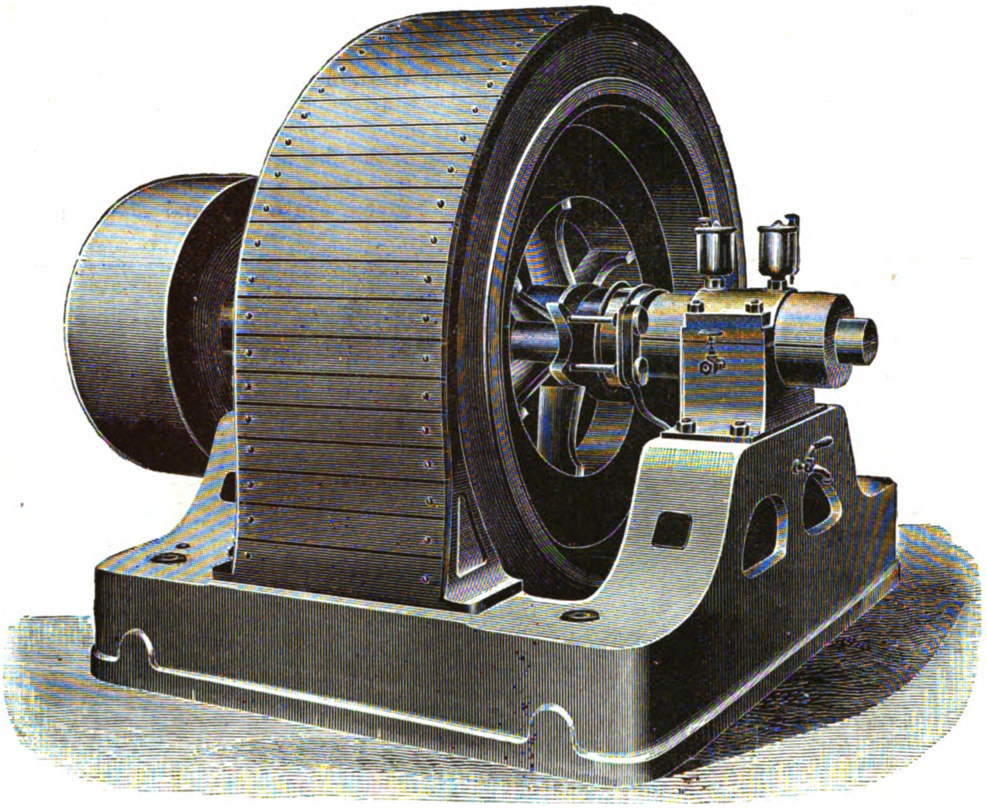
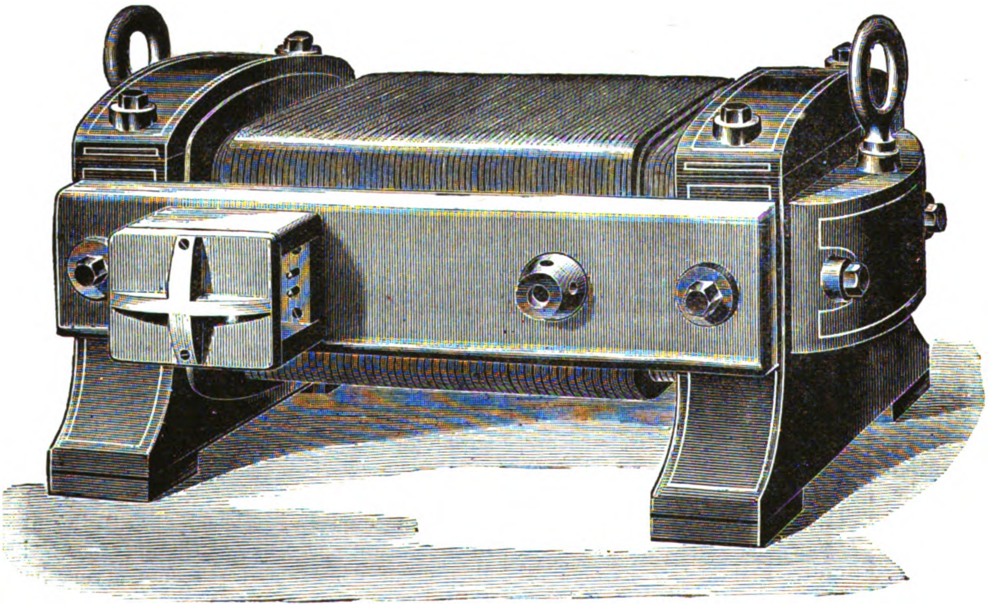
led off into the chimney-shaft by a pipe from the pit. The dynamo and engine-room is entered through another partition, and is certainly a very pretty and well organised arrangement of plant. The effect, even on looking at the present three sets of dynamos, as shown in our illustration of the engine-room, is very fine, and when the whole of the proposed plant is at work will be one of the finest exhibitions of machinery in London. A noticeable feature is the air of cleanliness and quiet—almost of solemnity, after the rattling of some dynamo-rooms—which is obtained by the beautifully-balanced slow-moving engines, the boxed-in dynamos, and the rope gearing. No difficulty is to be expected on the score of nuisance of machinery.



Lowrie-Parker Dynamo.



Lowrie-Hall Transformer.

The arrangement of the foundations of the engines are a special point in this installation well worthy the attention of electrical engineers. Instead of simply laying blocks of concrete, very often the only foundation, the foundations here are laid out with strong walls in hand-pressed gault bricks set in cement, and built directly to take the strain of the belting between the engines and dynamos, afterwards filled in with concrete. Party walls are placed to take the side strains, and foundations for the exciting dynamos are built in a similar way. The engine foundations are separated entirely from the outside walls, which are thus subjected to no strain from the machinery.

ENGINES.

The engine-power consists at present of three horizontal coupled compound engines, built to the specification of Mr. William Lowrie by Messrs. John Fowler and Co., Leeds, capable of indicating easily 250 h.p. Steam is cut off from the high-pressure cylinder before the piston has completed more than one-third of its stroke. The details of the engines are as follows: High-pressure cylinder 15in. diameter, low-pressure cylinder 25in. diameter, stroke of engine 30in., initial steam pressure 150lb. per square inch, speed 88 revolutions per minute, approximate weight of engine 24 tons.

The cylinders are fitted with separate liners, accurately turned to places, and forced into position by hydraulic pressure. Both cylinders are steam jacketed, the low-pressure cylinder jacket being supplied with steam from the intermediate receiver. Both ends of cylinders and valve-

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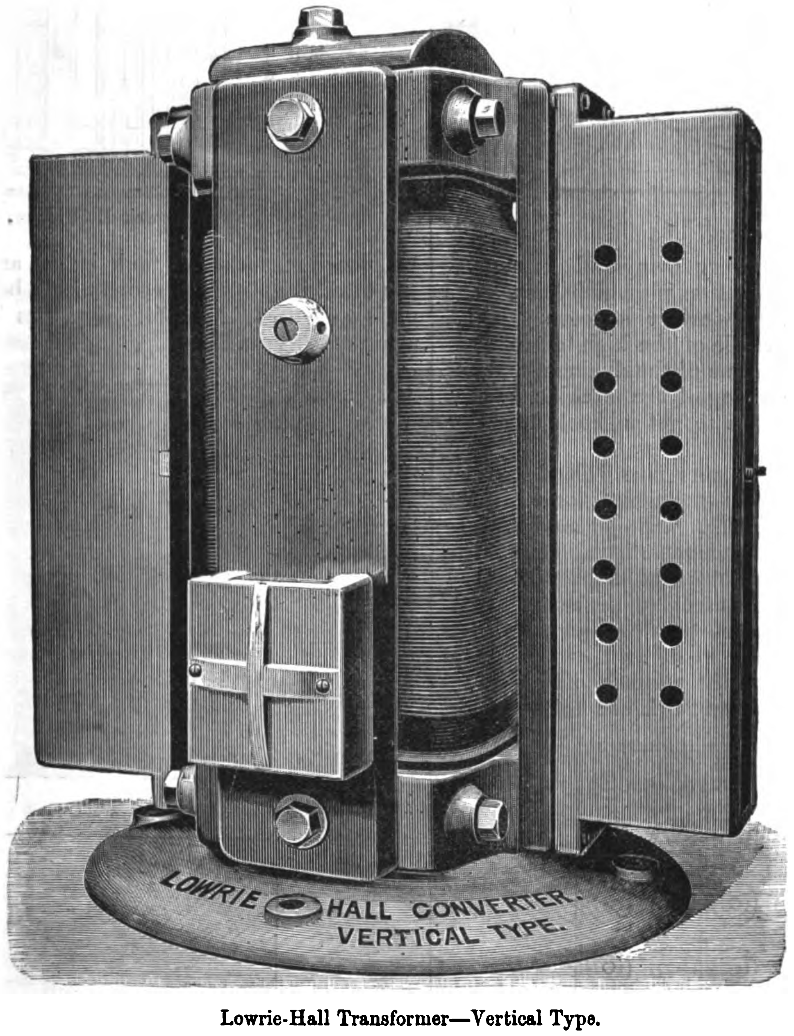
chests are fitted with large waste water-cocks with long barrels, close ends and glands, and coupled direct to a main drain pipe. All the cocks on each cylinder are joined together by rods and levers, and brought, with handle, within easy reach of the man standing at the starting valve, and all glands throughout have oilcups formed in the flanges and fitted for syphons. Cylinder lubricators are fitted to both valve-chests, and an extra sight-feed cylinder lubricator is fitted to high pressure steam-chest. The low-pressure cylinder is fitted at both ends with automatic relief valves; both valve-chests are provided with a 7in. steam pressure gauge and cock. All outer surfaces exposed to radiation are covered with a non-conductor and finished with sheet steel lagging. The steam feed is from above, the connecting pipe between high and low pressure cylinder dips beneath the ground line, and the exhaust is from the bottom side of the low-pressure cylinder. The main bearings are enormously strong: each is cast in one piece with the base plate, and fitted with brasses of the very best gunmetal, arranged for top and side adjustment; these bearings are 16in. long, and provided with two combined sight-feed and syphon lubricators, oil throwers, and catchers. Each engine is fitted with a heavy flywheel 14ft. diameter, made in halves, planed and joined through the centre, turned on the edges, and with turned grooves on the face, for driving with seven ropes, 1½in. diameter. The governor is Hartnell's latest patent, driven from the shaft by four cotton ropes, and controls the engine by acting directly on both the high-pressure and low-pressure expansion valves, giving a range of cut off in the high-pressure cylinder from 1 per cent. to 60 per cent. of the stroke, and governing the engine to within 2 per cent. A complete set of indicating gear is fitted to each cylinder, and a very neat little speed counter by Schaeffer and Budenberg, which can be reset to zero by a few turns of the key, counts the number of revolutions every day.

Dynamos.

The dynamos are Lowrie-Parker dynamos, designed by Mr. Lowrie, and made to specification by Elwell-Parker, Limited, Wolverhampton, and patented by Messrs. Lowrie and Parker (specification No. 12,907, 1888). They are multipolar alternating-current machines, capable of maintaining, economically and safely, an output of 100,000 watts. The dynamos are worked well within their limits, the current in the armatures never rising above 2,000 amperes per square inch of section. The working E.M.F. is 2,000 volts, the number of alternations 10,000—or 5,000 complete phases per minute (83 phases per second). The speed is 380 revolutions per minute, and the mean speed at the revolving surface is about 6,000ft. per minute.

The machine is the same as first employed at Eastbourne and Brighton, but sundry small improvements have been introduced. The Lowrie-Parker dynamo is designed upon the principle of fixed armature and revolving field-magnets, but, unlike Mordey's machine of this type, iron is largely employed in the armature.



Lowrie-Hall Transformer—Vertical Type.

Mr. Lowrie considers the use of armatures without iron disadvantageous, for the reason that the rapidly rotating magnet must tend to drag round the strongest portion of the field out of position of greatest utility. The greatest point of interest about these machines is the fact that nearly the whole of the copper strip in the armature—about 87 per cent. of the whole—is in the active part of the field, only a small portion of the coils, and those the turns lying parallel to the direction of rotation, being idle, rendering the machine both economical of copper and extremely efficient. The construction of the dynamos can be readily understood from the sketches of the details which Mr. Lowrie was kind enough to give us. The armature consists of a large outer ring built up of laminated iron discs, 5ft. in diameter and 5in. wide. On the inner face of this ring are simply planted the copper coils, which are kept in place by wooden strips screwed to the outer frame of the dynamo. These coils are wound upon a core of wood, very slightly concave to the radius of the machine. The copper is in the form of strip, ⅜in. wide by 1 millimetre thick, insulated with braided cotton saturated in shellac, with some

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where about 30 turns on each coil. The end of the strip is connected in series to the inner end of the next coil.

There are 28 coils lying thus on the face of the armature-magnet, the ends being taken inside the frame to two terminals inside a small cupboard in the casing of the dynamo. Connection is also made with a single coil, and from these all measurements with ammeter and voltmeter are made. The construction of the standing armature

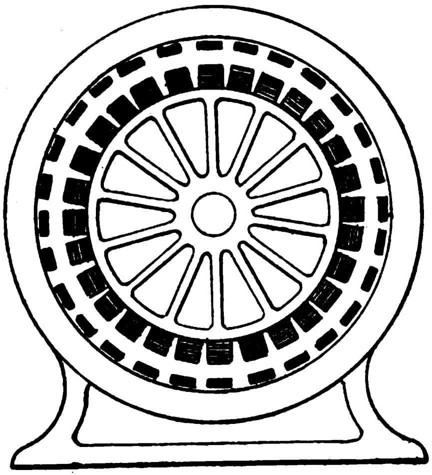
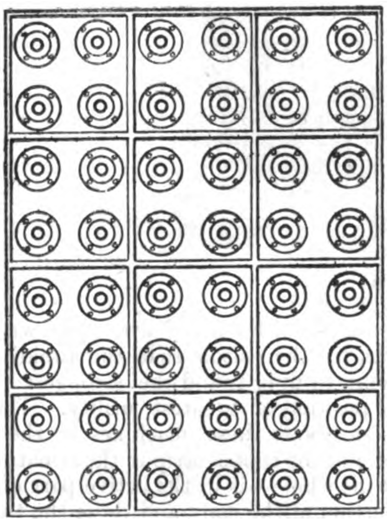


Diagram of Dynamo.

with the outer iron ring is thus very strong and permanent, and no fear of bending or side motion is possible, as may be the case with armatures—revolving or stationary—with simple built-up strips. The whole of the high-tension connections are made inside the frame of the dynamo, and the two terminals are inside the casing of the machine, so that it is impossible for a workman to get a shock unless he unscrews the casing.

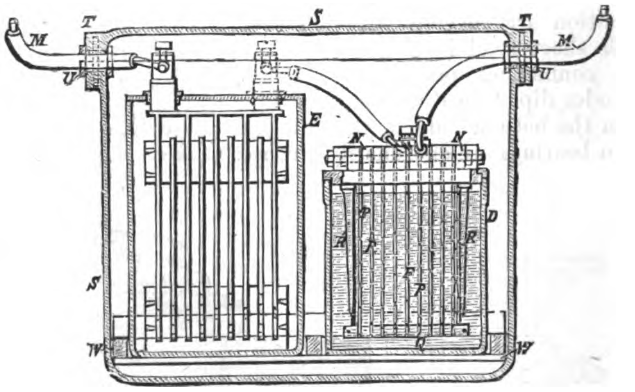
The magnets, also 28 in number, are bolted to the circumference of a 2½in. solid soft iron wheel, forged, without weld, out of one solid piece. Special methods are adopted to prevent the magnet-coils from flying off by the tangential force of rotation, the arrangement of which can be seen in the sketches. The cores of the magnets are rounded at the corners to allow of easy winding, but the edges are left sharp at the outer part, and serve as projections to carry the collar of the magnet-coil. Two T bolts pass through the magnet-core, and are bolted firmly



Switchboard.

to the iron ring. The arms or spokes carrying the iron ring occur at alternate magnets, so as not to magnetically short-circuit the cores. The magnets are wound with No. 8 wire, and carry eight amperes exciting current. An incidental advantage of this dynamo may be mentioned, and it is, that instead of, as usual, the E.M.F. dropping in working under full load as the machine gets hot, the construction of the magnet ring, on any heating taking place, expands the ring and pushes the magnets slightly closer to the armature, increasing the strength of the field. The E.M.F. is slightly higher when heated than when cool.

The bearings of the dynamo are exceptionally strong and heavy, so that there is little fear of heating; but, in case of emergency, the bearings are all water-jacketed with supply from the water-tank, so that a constant stream of cold water can be carried around them. The bearings are split, and the tops can be easily lifted off. The brasses are made so that the lower brasses can be revolved in their grooves, and knocking out for repair or replacement. All lubricators are combined syphon and sight-feed. The bearings, 20in. long, with side collars on one bearing to take side play. They are fitted with double oil grooves to catch the waste



Lowrie-Hall Meter.

oil, which is run into a tank below and used again. The use of oil is extremely economical; best pure hydro-carbon oil is only used, tested for impurities before use, and used again and again.

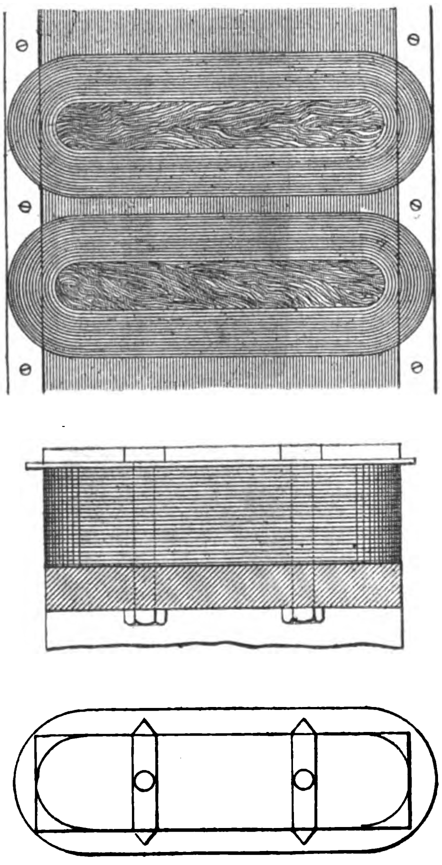


Diagram of Coils: Plan and Elevation of Magnets.

At Eastbourne, the oil consumption is stated as being only one quart of this oil in a year—practically, only the loss from tap-drippings. The lubricators on the engines also are all standing, arranged not to be in the moving parts, and are all fitted with combined syphon and sight-feed lubricators.

The exciting current is supplied by a small Elwell-Parker dynamo. A tachometer, by Schaeffer and Budenberg, Magdeburg and Manchester, is run from the axle of the dynamo for indication of speed. The weight of the dynamo is 10 tons.

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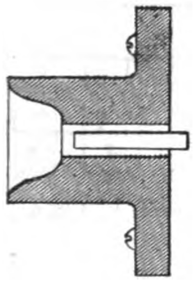
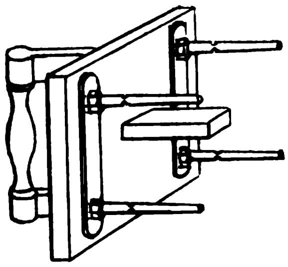
Tightening arrangements are made for adjusting the rope gearing. Around the dynamos is a highly insulated platform raised 6in. from the ground, of crossed floorboards on joists, with bitumen between the joists, and linoleum over all.

Switch and Test Room.

All wires are brought underground to the testing-room, and are brought up at the back of the switchboard. All connections are made behind, and it is impossible accidentally to touch the high tension connections. The switchboard is constructed in chinaware, mounted on ebonite, of the form shown in sketch ; connection between the dynamos and mains is made by insertion of the connecting-block with four brass pegs. This slides in the china cups, and it is impossible, by reason of distance of pegs, to short-circuit the dynamo. Any circuit can be connected to any dynamo—as shown in the diagram of circuits.

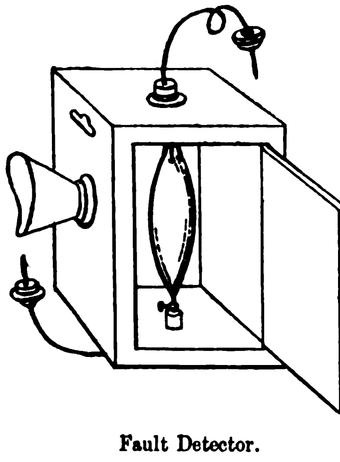


Section of China Cup of Switch.

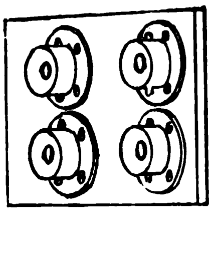


Connecting Switch.

The regulation of the dynamo is effected to within a variation of 1 per cent. by the Lowrie-Hall regulator, already fully described by us (vol. ii., pp. 283, 319). In this the heating effect of the alternate current is utilised. The sag in a long iron wire lengthened by heating, moves, without the disadvantage of friction, a tipping lever which sends an electric current one way or other, and alters a liquid resistance inserted in the exciting circuit. The action is very perfect.



Fault Detector.



China Switch Blocks.

An ingenious method, devised by Mr. Lowrie, is used to test the insulation of the underground mains. On every circuit carrying high-tension alternating currents, a certain static charge is generated. If the insulation is perfect, this can only escape to earth at the dynamo terminals. This static charge is here utilised to show a glow discharge, when the switchboard terminal is connected to earth, in a vacuum tube, arranged in a dark box, with a funnel for inspection, as shown. The degree of luminosity seen is a test of the insulation of the mains.

The Underground Mains.

The mains are all to be laid underground in iron pipes, and special details have been worked out for the junction pieces and street boxes. Three sizes of pipe will be used, 3, 4, and 5in. diameter. The junction pieces for these are all arranged with the same size connecting plate and screw-holes, and the street boxes are, therefore, all of one size The street boxes are constructed in two parts, the upper one with lid and spring lock, to be easily got at, the lower box being able to be set in the roadway when repairing, and filled up to desired level with bitumen or concrete.

The mains themselves are of special make, being Tatham's insulated cable, supplied by Fowler and Co., Leeds. The insulation is the highest yet made for cables, being stated as 32,000 to 43,000 (thirty-two to forty-three thousand) megohms per mile tested under water. The insulation consists of nine braidings saturated with a patent solution, and the cable is then lead-covered, and has a coating of hemp over all. The cables are made in five standard sizes, for supply of 2,000, 1,500, 1,000, 500. and 250 16 c.p. 50-watt lamps at the distance of one mile, with a loss of 2 per cent., the latter size being the least that is convenient for mechanical reasons. The cables are simply drawn through the cast-iron pipes. The leads have already been laid along Braham-gardens, Barkeston-gardens, Collingham-gardens, etc., and some forty houses are wired ready for connection.

Transformers and Meters.

The transformers used by the House-to-House Company are shown in the illustrations. Two forms are used, upright and horizontal, for use according to the position. The Lowrie-Hall meter has been fully described by us (see vol. ii., p. 248). Its action may be briefly described as a combination of secondary cell and electrolytic cell; the alternate current not having any effect upon the electrolytic cell, the secondary cell acts in its own direction along the circuit proportionately to the number of lamps alight, the electrolytic effect being thus the measure of the current.

The whole of the electric machinery and apparatus is distinct from other systems, and is practically all new and original with the company, designed and carried out under the supervision of the engineers, Messrs. Lowrie and Hall.

Congratulatory speeches to the House-to-House Company were made at the dinner at Bailey's Hotel by Mr. Preece, Prof. Forbes, and others, but we have no space to do more than allude to them. (For further illustrations see next page.)

REPORTING AT THE INSTITUTION.

To the Editor of The Electrical Engineer.

Sir,—Surely the council of the above Institution have committed a blunder by prohibiting the Press reporting papers, etc. I am afraid this must have a serious effect upon the membership. We in the provinces have always been heavily handicapped, and now we will know nothing of the Institution's proceedings until months after. Surely the fact of our being debarred from the use of the library unless we visit it (a benefit which is also given to the general public), might have caused the council to consider carefully before they applied the closure to the Press. We cannot deny there has been a vast amount of gratuitous advertising done at our meetings; but it is well known that the greatest sinners in this respect have, at one time or other, been members of the council. Why should there be any difficulty in so arranging matters that our worthy secretary should, with a few strokes of the pen, make short work of such advertisements ?—Yours, etc.,

A Provincial Member.

Glasgow, 29th January, 1889.

RED WIRE v BLACK.

To the Editor of The Electrical Engineer.

Sir,—In specifications for wiring it is frequently stipulated that red wire be used for the leads, and black for the return.

Although there may be some slight advantage in this arrangement, we feel sure that no one would wish to insist upon its adoption at a sacrifice of efficiency.

We have invariably found, especially in damp situations, that the red wire shows a marked inferiority both in insulation and durability, and we shall be glad to hear whether this is confirmed by the experience of other electric light contractors.

We may add that this applies to wires of all manufacturers that we have employed.—Yours, etc.,

Drake and Gorham.

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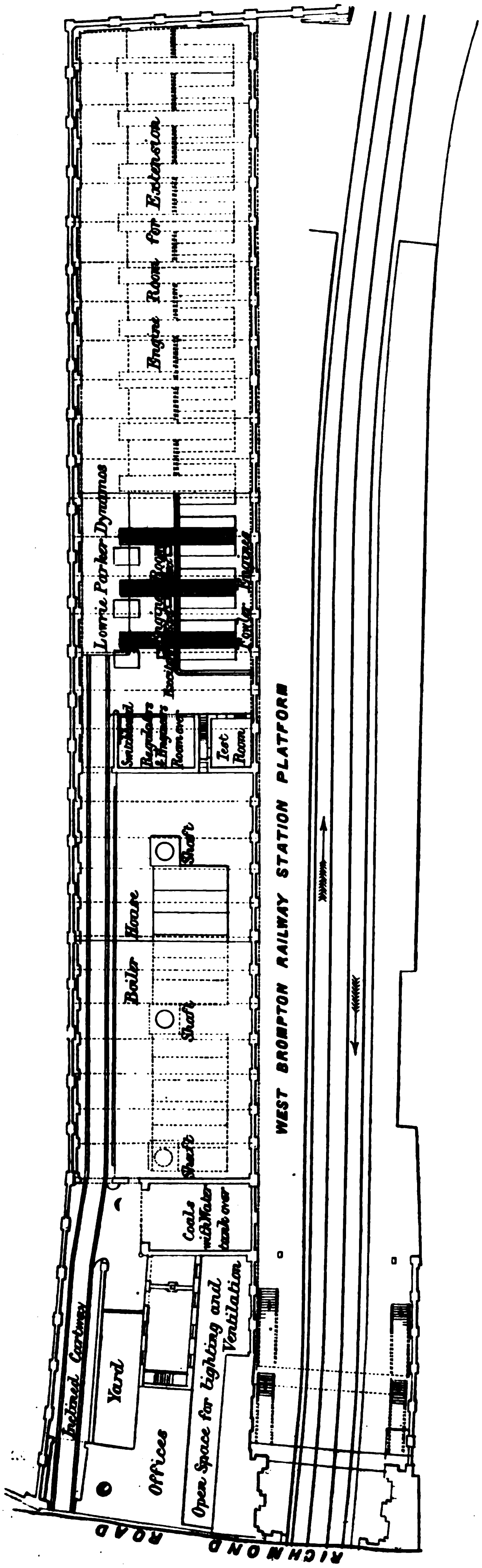
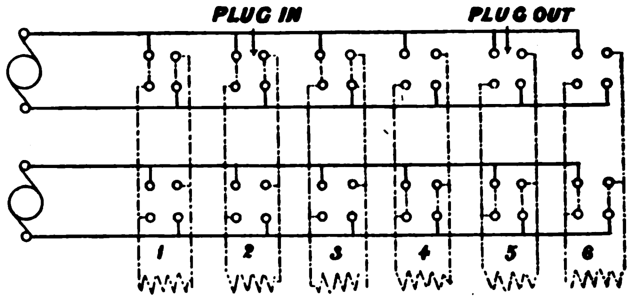
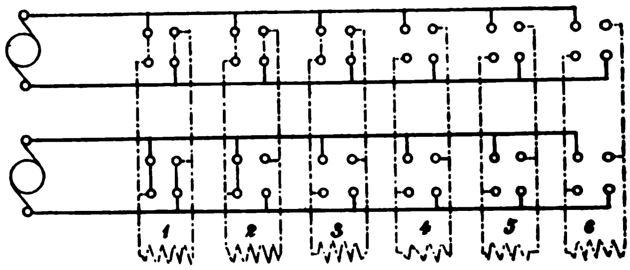


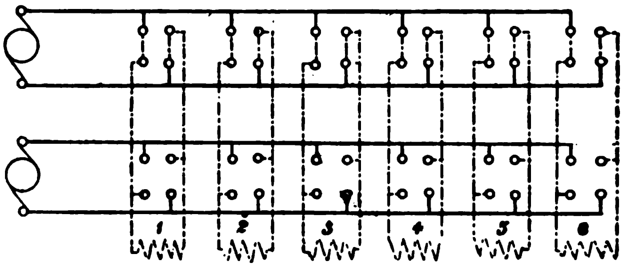
PLAN OF HOUSE-TO-HOUSE CENTRAL STATION, WEST BROMPTON.



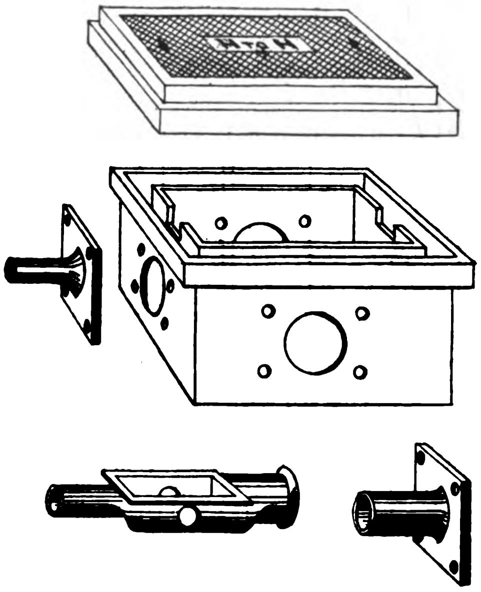
Dynamos 1 and 2, connected to three circuits each.



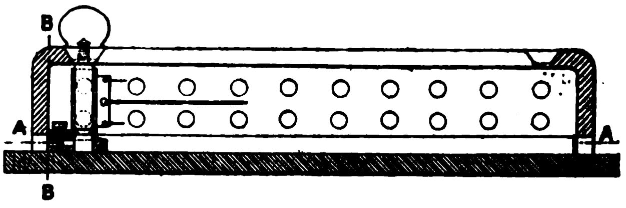
Dynamos 1 and 2, coupled to three circuits to connect 4, 5, 6.



Dynamo 1, coupled to all circuits.



Street Boxes, Sockets, and Junctions.



Fuse Block.

(FOR DETAILS, SEE PAGE 89.)

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THE

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All communications intended for the Editor should be addressed C. H. W. BIGGS, *139-140, Salisbury Court, Fleet Street, London, E.C. Anonymous communications will not be noticed.*

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

INAUGURATION.

Many writers have divided mankind into two classes, though the names given to the classes are not always the same, so we may venture to divide companies into two classes, one of which includes those that intend to work, the other includes those who don't so intend. Happy is the managing director of the former concern, when after promotion and organisation he can invite his co-directors and the public to see for themselves that work is going on satisfactorily and successfully. Now we were among those who might be said to have written hard things about the House-to-House Company, but we never for a moment doubted the settled intention to proceed energetically to work. Financial arrangements may be looked upon with suspicion, while good, sound commercial work may receive its own modicum of praise. There is no intention to discuss the ever open question of advisability of a central station here or of a central station there, of competing companies, of overhead or underground distribution, or of alternate v. direct current supply. There is undoubtedly a new, and we hope a permanent, development of the electric lighting industry, and without demur from anywhere we fancy that the new station of the House-to-House Company at Brompton may be recorded as a proof of it. Kensington Court, the Grosvenor Gallery, and the Whitehall installations are, if not old friends, specimens of the energy of those workers who never lost hope, while that at Brompton is the work of a recently formed company, which will no doubt ask the public ere long for further support. The directors have something to show for the money previously invested, and it will be for them to make out a good case for further confidence. When the time comes for this operation, we shall probably have an opportunity of testing the statements and saying something on the subject; meanwhile our remarks will stray no further in this direction.

So far as experienced judges can ascertain, the details of this installation have been carefully thought out; and if any weakness is suspected, it may perhaps be in the mechanical details of the dynamos. It speaks well of the engineers that free access has been given to their colleagues in the profession to inspect every detail. Mr. Lowrie must have been pretty certain of himself and of his plans before he submitted them to the examination they have undergone.

The principal guests at the inaugural ceremony, described more technically elsewhere, no doubt were invited for various reasons, and their opinions upon technical matters are valueless. Most of them would know an engine from a dynamo—when they were told, but further their education has not gone. Other guests, however, at the ceremony were designers of other stations, and they were fully able to appreciate

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the difficulties that have been encountered and overcome. When central stations become as plentiful as gas works, when those engineers who have designed them are reckoned by hundreds and not by units, then, and not till then, will the designing of such work be undertaken with a feeling akin to indifference, such a feeling being engendered by a thorough knowledge of what has been done in numerous cases, how it has been done, and with what amount of success. The engineers of the Brompton station have received a certain apprenticeship at Eastbourne; they have there succeeded, and have here followed the lines dictated by their own experience. Precautions have been taken to enable the plant to be increased without difficulty to about three or four times its present capacity.

Reference may be made to certain remarks of Prof. Forbes and Mr. Preece in their speeches at the dinner after the inspection of the works. Both gentlemen compared the lighting of the streets of American towns with the lighting of streets in English towns, and the comparison was not flattering to England. Mr. Preece ought to know if anyone does, for his experience with them is great, that the ruling powers of the greatest city under the sun, who should have been among the first to welcome and introduce more light, are about the most difficult to change from the error of their ways. Procrastination is writ large all over the City, and those who arrogate to themselves the ideality of business acumen seem to know little and care less about the economic value of more light. The whole cry is, It costs more. So does the advertising of Pears over that of little Pedlington Smith, and yet Pears says it pays. The City fathers can't and won't see it in this light. To them more light does not mean more business, more quickly done and at less cost: it means one penny in the pound. Perhaps the rude remarks that have been made will assist in helping the "powers that be" to screw their courage up to the required point, and to not only advertise for tenders, but to plunge boldly and manfully into the work of giving more light in London streets. We don't want anything similar to gas; we want more, more, more. The inauguration of the Brompton station will prove how quickly, after the word to start is given, plant can be erected to give twenty, forty, sixty, or a hundred-thousand lights. It seems but yesterday the House-to-House Company was floated, and yet building and plant are ready to produce revenue. Next winter ought to see sufficient progress made to enable electric supply companies to supply current to light half London. We should like to here repeat our often reiterated remarks that if the companies would only keep as prominently before them the supply of power as they do that of light, what a boon they would confer upon commercial humanity, and their own shareholders.

THE SOUTHWARK SUBWAY.

From time to time rumours, more or less authoritative, have been floating about as to the motive power to be used on this line. The report of the company, which we give elsewhere, shows that the matter is at last definitely settled, and that Messrs. Mather and Platt have the work in hand. Our readers know how strenuously we have advocated electric as against every other form of traction in this subway, and though we knew of early negotiations with Mr. Holroyd Smith, and subsequently with Messrs. Siemens, we also knew that strong efforts were being made to put aside electricity in favour of other means of traction. However, all is well that ends well, and we have no fear of the success of electricity in the hands of the Bros. Hopkinson and Messrs. Mather and Platt.

The method of construction and the system of working of the City of London and Southwark Subway mark a new departure in the methods of communication in our large towns, and will probably afford a complete solution of the problem of underground railways.

The subway consists of two tunnels, each 10ft. 6in. in diameter, formed of segmented cast-iron plates. It extends from the Stockwell terminus at Clapham-road, by the Oval and the Elephant and Castle at Newington, and then under the Thames to the City terminus at King William-street, the total length of each tunnel exceeding three miles. There will be stations at the Monument, King William-street; Great Dover-street; the Elephant and Castle; the Oval; and at Stockwell.

As the method of construction, which is entirely novel, has been already frequently described, and interests mechanical and civil, rather than electrical engineers, we need not allude to it more particularly now, but, as we have said, it is only quite recently that the system of traction to be adopted has been definitely decided.

The original Act of Parliament specified that the traffic shall be worked by means of carriages, propelled upon the system of the cable tramway, but about a year ago the success of the Bessbrook and Newry Electrical Tramway and other similar undertakings led the directors to consider the adoption of electrical working, and they entered into communication with Messrs. Mather and Platt, of Manchester, on whose behalf Dr. Edward Hopkinson, the managing partner of their electrical department, prepared a detailed and elaborate scheme.

The matter was under discussion for some months, and finally tenders were invited from the most eminent electrical engineering firms. The result has been that the scheme of Messrs. Mather and Platt has been adopted in its entirety as affording a perfectly satisfactory and feasible solution of the problem, and a contract has been placed with them for the carrying out of the entire work.

The generating plant will be placed at the Stockwell terminus, where boiler and engine plant of over 1,000 h.p. will be erected and three large Edison-Hopkinson dynamos. The current will be conveyed by a lead-covered cable throughout the whole length of the line, and Dr. John Hopkinson's system of overhead conductors will be adopted for conveying the current to the locomotives.

This system has proved a great success on a small scale at Bessbrook, and is particularly well adapted for such an undertaking as the subway.

There will be 14 electrical locomotives, each capable of developing 100 h.p., which is sufficient for moving a train containing 100 passengers at 25 miles per hour, and for providing the great power required for starting rapidly.

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ELECTRICITY v. GAS.

Price per Board of Trade unit. New unit = 10 old units		Equivalent price per 1,000 cubic feet of gas (calculated on assumption that a 16 c.p. gas burner takes 5 cubic feet per hour, the glow lamp being taken at various efficiencies of from 2¼ to 4 watts per candle-power). WATTS.							
Old unit.	New unit.	2¼	2½	2¾	3	3¼	3½	3¾	4
d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
2·4	2 0	1 5·3	1 7·2	1 9·1	1 11·0	2 1·0	2 2·9	2 4·8	2 6·7
2·7	2 3	1 7·4	1 9·6	1 11·8	2 1·9	2 4·1	2 6·2	2 8·4	2 10·6
3·0	2 6	1 9·6	2 0·0	2 2·4	2 4·8	2 7·2	2 9·6	3 0·0	3 2·4
3·3	2 9	1 11·8	2 2·4	2 5·1	2 7·7	2 10·3	3 1·0	3 3·6	3 6·2
3·6	3 0	2 1·9	2 4·8	2 7·7	2 10·6	3 1·4	3 4·3	3 7·2	3 10·1
3·9	3 3	2 4·0	2 7·2	2 10·3	3 1·4	3 4·6	3 7·7	3 10·8	4 1·9
4·2	3 6	2 6·2	2 9·6	3 1·0	3 4·3	3 7·7	3 11·0	4 2·4	4 5·8
4·5	3 9	2 8·4	3 0·0	3 3·6	3 7·2	3 10·8	4 2·4	4 6·0	4 9·6
4·8	4 0	2 10·6	3 2·4	3 6·2	3 10·1	4 1·9	4 5·8	4 9·6	5 1·4
5·1	4 3	3 0·7	3 4·8	3 8·9	4 1·0	4 5·0	4 9·1	5 1·2	5 5·3
5·4	4 6	3 2·9	3 7·2	3 11·5	4 3·8	4 8·2	5 0·5	5 4·8	5 9·1
5·7	4 9	3 5·0	3 9·6	4 2·2	4 6·7	4 11·3	5 3·8	5 8·4	6 1·0
6·0	5 0	3 7·2	4 0·0	4 4·8	4 9·6	5 2·4	5 7·2	6 0·0	6 4·8
6·3	5 3	3 9·4	4 2·4	4 7·4	5 0·5	5 5·5	5 10·6	6 3·6	6 8·6
6·6	5 6	3 11·5	4 4·8	4 10·1	5 3·4	5 8·6	6 1·9	6 7·2	7 0·5
6·9	5 9	4 1·7	4 7·2	5 0·7	5 6·2	5 11·8	6 5·3	6 10·8	7 4·3
7·2	6 0	4 3·8	4 9·6	5 3·4	5 9·1	6 2·9	6 8·6	7 2·4	7 8·2
7·5	6 3	4 6·0	5 0·0	5 6·0	6 0·0	6 6·0	7 0·0	7 6·0	8 0·0
7·8	6 6	4 8·2	5 2·4	5 8·6	6 2·9	6 9·1	7 3·4	7 9·6	8 3·8
8·1	6 9	4 10·3	5 4·8	5 11·3	6 5·8	7 0·2	7 6·7	8 1·2	8 7·7
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10·2	8 6	6 1·4	6 9·6	7 5·8	8 1·9	8 10·1	9 6·2	10 2·4	10 10·6
10·5	8 9	6 3·6	7 0·0	7 8·4	8 4·8	9 1·2	9 9·6	10 6·0	11 2·4
10·8	9 0	6 5·8	7 2·4	7 11·0	8 7·7	9 4·3	10 1·0	10 9·6	11 6·2
11·1	9 3	6 7·9	7 4·8	8 1·7	8 10·6	9 7 4	10 4·3	11 1·2	11 10·1
11·4	9 6	6 10·1	7 7·2	8 4·3	9 1·4	9 10·6	10 7·7	11 4·8	12 1·9
11·7	9 9	7 0·2	7 9·6	8 7·0	9 4·3	10 1·7	10 11·0	11 8·4	12 5·8
1 0	10 0	7 2·4	8 0·0	8 9·6	9 7·2	10 4·8	11 2·4	12 0·0	12 9·6

The trains will run at intervals of three minutes, and will consist of three cars.

In addition to the plant required for electrical traction, Messrs. Mather and Platt's contract includes the lighting of the trains and of the stations, and of the hydraulic lifts and approaches.

The experience gained by Dr. Edward Hopkinson on the Bessbrook and Newry line, which, though on a much smaller scale, is still of the same character, and which has proved an unqualified success, has solved many difficulties in connection with electrical traction, and will be of great value in the present undertaking.

Mr. James Henry Greathead is the engineer of the subway, to whose designs the entire works have been constructed. Sir John Fowler and Mr. Benjamin Baker are the consulting engineers, and Mr. Spagnoletti the consulting electrician.

CORRESPONDENCE.

LITHANODE.

To the Editor of The Electrical Engineer.

SIR,—I have been asked by our consulting electrician, Mr. D. G. FitzGerald, to forward you some samples of "lithanode," which I now do. Hitherto, by the policy of other companies who previously owned and worked the lithanode patents, it has been most jealously shielded from the public gaze, and no samples have been issued for experimental purposes to the public.

My directors, however, have decided to issue such samples in small quantities to anyone who does not mind the trouble of applying for the same, enclosing a stamped addressed label. The plates I now send you may be cut up into smaller ones by the aid of a fret saw, thus forming a powerful, though small, battery of many cells, and will give with zinc as cathode 2·375 volts per cell; each ounce of

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material will give one ampere-hour discharge in ordinary diluted sulphuric acid of specific gravity 1·170. The small plate will show the best mode of contact, but carbon blocks or rods bound on to the lithanode, or Bunsen battery clamps, with platinum foil, will answer the purpose.—Yours, etc., OSWALD SWETE, A.I.E.E.

The Mining and General Electric Lamp Company, Limited, Guildford-street, S.E. January 29, 1889.

CENTRAL STATIONS WORKED BY UNDERGROUND MAINS.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I have just noticed in a back number of *Engineering* (March 23, 1888) a letter, which I send you, bearing on central stations worked by underground mains. Placed alongside the repeated and positive assertions of the House-to-House Company, it appears peculiarly interesting. Some of your readers may know of other instances in practical use.—Yours, etc., ONLOOKER.

"Sir,—I have read with pleasure Mr. Geipel's paper reprinted in your issue of March 9th (page 238), and beg to be allowed to correct several erroneous assertions in that paper. It states that, with the single exception of Eastbourne, there are no electric illumination plants on a large scale worked by the current from transformers and with underground conductors. Now as concerns this country (Italy) I am happy to state that during more than two years we have three very considerable central transformer installations, supplied with the well-known Zipernowski-Deri-Blathy system, which are entirely worked by underground conductors. The largest of these working installations is that done by the Anglo-Roman Gas Company, which lights already daily upwards of 5,000 lamps, and is continually extending. The other two plants, although not so large as that of Rôme, still are of very considerable extent; they are in the hands of the Italian Edison Company, Milan, and of Messrs. Bellair Brothers, Turin.

"All the underground conductors for these installations have been manufactured by the house of Siemens and Halske, of Berlin, who have taken special precautions for ensuring an irreproachable service, and have succeeded in making cables without perceptible waste of current by induction. These conductors are composed of two highly insulated concentrical conductors, protected against external and mechanical influences by a lead sheath and a double spiral band of iron. Upwards of 40,000 metres of such conductors have been laid in Italy alone, and nobody has ever complained of them

"Should you find it desirable I can give you further details. You would oblige by publishing these remarks.—

"I am, sir, yours truly, "EMILIO MAGATTI,

"Engineer to MM. Fratelli Moleschall.

"Rome, March 14, 1888."

[We take it that the references of the House-to-House Company are primarily to be taken as relating to England, where, with certain modifications, they may be regarded as approximately correct. As a rule, the work at Eastbourne is that regarded as the pioneer underground work. In London we have now the Kensington Court installation, not altogether in its babyhood, and the Whitehall installation, both actually at work.—ED. *E. E.*]

GAS ENGINE CENTRAL STATIONS.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Electric lighting makes very slow progress in Britain; we often enough hear this, and it is a truism. We have now central stations in the principal towns in England, also in Glasgow, but the difficulties thrown in the way of establishing a central supply station in a town in the North makes one wonder that even so much progress has been made. In smaller towns than those above referred to, it is advisable, if possible, to prevent the gas and electrical interests clashing; however, the gas companies do not attempt to meet you half way. In a certain place, not unknown to those who seek the country for health or pleasure, it was proposed to erect a small central station as a pioneer of more extensive development to follow later on. The gas company, however, on being asked to treat with regard to the use of their product in gas engines as prime movers in an electrical plant, gave grudgingly a very minute reduction in price, and so saddled it with conditions as to laying mains to the works and so on, that it practically throws such a proposal out.

It appears to be a prevalent opinion amongst gas engineers that the use of an engine on any gas main will cause all the lights on that pipe to flicker and pulsate even with the modern anti-fluctuators now in use. Can we wonder that electricians do not attempt to harmonise with the gas interests, and also that electric lighting is so far behind our cousins in the States?—Yours, etc.,

C. H. YEAMAN.

Glasgow, January 25, 1889.

ELECTRIC METERS FOR CENTRAL STATIONS.*

BY PROF. GEORGE FORBES, F.R.S.

(Concluded from page 80.)

Ferranti Meter.—The next meter which I wish to describe is that of Mr. Ferranti. It is one so beautifully simple in its principle as to please one at first sight. It is founded on the principle that when an electric current passes through a fluid which is placed in a magnetised space, the fluid tends to move in a direction perpendicular to the current and to the magnetic action. The magnetic poles of circular form are placed one above the other, one being a north pole, the other a south pole. Between these two is a circular insulated trough containing mercury. The current enters the mercury at the centre of the trough, and the outer rim of the trough forms the other electric terminal where the current goes out.

The original instruments were intended for currents continuous in direction, and the magnets were excited by the electric current to a moderate amount, so that the magnetism was proportional to the current. Thus the moving force was proportional to the square of the current, and the friction of the mercury being approximately as the square of the velocity, the indications of the instrument would be accurate. Of course, the law I have spoken of is only true as a sort of approximation. The friction of the indicating mechanism follows a different law and affects the result. The number of rotations made by the mercury is indicated by the rotation of a float of special construction, resting on the mercury, connected by a spindle with a train of wheel work, which indicates the total number of revolutions. The meter has also been adapted for aberrating currents, and is rendered more delicate by having an additional shunt-winding of very high resistance. This circuit is put in multiple arc with the lamps on the two mains of the house supply. The friction of the wheel train is reduced to a minimum by employing the finest and lightest mechanism which can possibly be constructed. I am sorry to say that Mr. Ferranti has not been able to furnish me with any tests or specimens of his alternating-current meter, as he is even now introducing some improvements. I am told the range is about fifty fold, and that it is very accurate. I may mention, in praise of Mr. Ferranti's ingenuity, that both Mr. Edison and Mr. Weston, in America, two of the most prolific inventors, tried to work out a similar instrument and found it ineffective. The chief difficulty was one which, until Mr. Ferranti attacked the problem, has been taken as a universal fact—viz., that mercury is unsuited for a permanent contact. They found that the mercury got covered with a film or powder which interfered with its free movement.

Aron's Meter.—I now come to a very interesting type of meter, the principle of which was first suggested in this country by Professors Ayrton and Perry, and which has been made a practical instrument by Mr. Aron, in Germany. I have lately visited the central stations of Berlin, the largest existing on the Continent. These stations are the best equipped in the way of boilers, engines, dynamos, and accessories of any low-tension system I have ever seen. There is this defect, however, that they have hitherto used a distributing system with two instead of three wires. This fault will be remedied in the future. They supply at present current sufficient for a maximum supply of 26,000 incandescent lamps of 16 c.p. And here let me protest against the practice, beginning in this country, to take an 8 c.p. lamp as the normal one. Everyone is dissatisfied with the low candle-power prevalent in London, and, as a general rule, 16 c.p. lamps have been found in actual experience in hundreds of central stations to be the most suitable. The stations also light the Unter den Linden with 108 arc lamps of 15 amperes,

* Paper read before the Society of Arts, Jan. 23.

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and the Leipziger Strasse with 36 arc lamps. The former is the finest piece of street lighting ever accomplished.

All the incandescent lamps are charged for by meter, and the Aron meter is always used. Originally it consisted of an ordinary clock, with a permanent magnet for the bob of the pendulum; below this a coil of wire is fixed with its axis vertical. The current to be measured passes through this and repels the magnetic pole, thus diminishing the influence of gravity on the pendulum, and causing the clock to lose time. The loss of time in any period, as compared with a good, uninfluenced clock, shows the number of units of electricity which have passed through the instrument. It takes a long time to test such an instrument over its whole range, and I have not been able to obtain any tests. The chief inconvenience of the instrument in its old form was that a clock could not be depended upon for accuracy more than about half a minute a week. One minute a week would be the smallest registerable quantity. Suppose this means one lamp-hour, then the maximum loss of the clock in the week being 12 hours, the instrument could not register more than $12 \times 60 = 720$ lamp-hours per week. Another inconvenience was having to wind up so many clocks every week. The former defect has been got over by mounting two clocks on the same framework, one in its normal condition, the other governed by the current. The two trains of wheels are connected by a differential gear with a third train of wheels with dials and pointers like a gas-meter. This increases the range of the instrument, so as to be practical. Of course, this improvement diminishes the accuracy of the instrument (1) by introducing more work for the clocks to do, and (2) by having to deal with the ordinary errors of two clocks, and every clockmaker knows that two pendulum clocks mounted on the same frame affect each other's going, and introduce errors. The principle of this meter is very beautiful, and in the Berlin central stations the authorities speak in very high terms of its value. Complaints from customers do come in, but in those cases the meters are tested, and found to work quite well. Its range is greater than for any other meter, being about one hundredfold, I believe.

This meter has been altered to adapt it for registering alternating currents by replacing the permanent magnets by coils, or electromagnets. In the central station at Rome, which is in many points the finest and best-designed station for alternating currents which I have yet seen, it is intended to test these meters. But I can say nothing about their accuracy. I will only point out that in this case the retarding influence varies as the square of the current, whereas, with the permanent magnet, it varies as the current. This does not lead us to hope for the same satisfaction as is afforded by the type for continuous currents.

Lowrie-Hall Meter.—I will now say a few words about a meter specially designed for alternate currents, which resembles the Edison meter more than any other. This is the Lowrie-Hall meter. A battery—preferably a secondary battery—is placed on the secondary circuit of a transformer. An electrolytic cell is also placed in the circuit. Now there is no complete circuit through the battery and electrolytic cell except when lamps are in circuit, and it is only then that electro-chemical decomposition can take place. The alternate circuit does not transfer metal from one plate to another. The whole effect in this way is produced by the battery, which acts as if the alternating current did not exist. The continuous current thus flowing is proportional to the conductivity of the current—*i.e.*, to the number of lamps at work. Thus the total number of lamp-hours, or Board of Trade units, is measured by the quantity of metal lost by one plate or gained by the other. This is an extremely novel and ingenious idea. One is inclined to ask how long the battery will stand the alternating current, and whether there is much trouble in charging and replacing the secondary batteries. I am informed that these meters have been successfully at work at Eastbourne for more than a year.

Schallenberger Meter.—A very practical form of meter has lately been brought out by Mr. Schallenberger, electrician to the Westinghouse Company at Pittsburgh, an extremely ingenious and accomplished electrician. It is intended for use only with alternate currents. This is not the place to go into a scientific examination of the theory of its action. I will try to explain it in popular language. A circular iron disc is placed on a vertical arbor connected with the correcting mechanism, and also carrying a fan to introduce resistance to movement by air friction. The iron disc rotates very freely. Two diameters of this disc are chosen, inclined to each other at 45deg. A coil of wire or copper ribbon fixed to the casing is coiled round each of these diameters. One of these coils is connected with one of the wires going to the lamps, and consequently has an alternating current flowing through it. The other coil is closed on itself, and has induced currents attaining a quarter of a period later than the main current—*i.e.*, when the main current is zero. Now consider the instant when the main current is a maximum. It magnetises the iron disc, and a quarter of a period later the induced current, acting at an angle of 45deg., tends to turn the disc in a certain direction. When the main current is reversed the magnetism is reversed, and the secondary current is also reversed, and hence rotation in the same direction ensues. Thus we have continuous rotation of the iron disc when an alternating current is flowing through the main coil. It is found that for a 15-fold range the number of revolutions of the disc indicate the total number of lamp-hours, or Board of Trade units, which have passed. This is a very convenient type of meter. It does not require great delicacy of construction, and is not liable to get out of order. The objection to it is that its indications vary with the speed of reversals of the alternating current, and our best governors are not perfect, and our most reliable suppliers of electricity would be tempted to alter its indications by increasing the speed of the engines a little. But the meter remains a beautiful practical instrument, which is doing splendid work in the United States. Mr. Schallenberger promised to send me one of these meters, but I am sorry to say it has not yet arrived.

Forbes' Windmill Meter.—Some years ago, when I first realised the value of the invention of Messrs. Gaulard and Gibbs, for distributing high-tension currents in the mains and delivering it as low-tension in the houses, I felt that one difficulty in the way of adopting it was the want of a meter for alternating currents. Such a thing did not exist, and I felt certain that the public would never be satisfied with a meter whose indications depended on the speed of reversals. It seemed to me that the heating quality of the currents was the only one which would succeed, and would be equally applicable to continuous and alternating currents. I was fortunate enough to have the kind assistance of Mr. A. Stroh for perfecting the details, and eventually the windmill meter was completed, in which the heat generated in a resistance sets up convection currents in the air, which work a kind of windmill. Here the force is proportional to the square of the current, and the opposing resistance is air friction, which varies as the square of the velocity, so that it was natural to expect that the indications would be accurate, and this was found to be the case.

The windmill which I use is made of a mica disc, with mica vanes round the edge attached to it by small pieces of pith. It has a hole in the centre, in which is fitted a thin paper cone, which has at its apex an aluminium cone, supporting a steel pinion with a ruby cup in its centre. This cup rests on a needle point, and the pinion works into the train of wheels which does the counting.

When this meter was perfected, it seemed that the English demand was not great, and it was best to modify it to suit the American market. I went to America to find out exactly what was wanted, and altered the instrument accordingly. The chief objection raised to it was the difficulty of mailing it, and a fear that it was too delicate. Consequently, I strengthened some of the parts, reduced the sharpness of the needle point and provided a metallic case in place of a glass shade. A considerable number have been sent across the Atlantic in both directions without any injury by the ordinary channels. On arrival all that has to be done is to loosen a screw, so as to free the windmill and let it play upon the needle point. The electric resistance of the conductor has also been objected to. This I was able to correct by altering the form of the conductor in which the heat is produced. Its resistance is now one-hundredth of an ohm, and Mr. Schallenberger after testing, at Pittsburgh, a batch which were sent direct from the workshop without any adjustment, wrote to me saying that they are quite accurate, and that the fall of voltage, due to resistance, is quite low enough, and that they were put to work on the regular commercial circuits. Mr. Westinghouse has acquired the rights for America, and is now manufacturing them at Pittsburgh. It is the only meter which he supplies for motors and continuous currents, and it also works equally well with alternating currents, of any speed of alternation. For alternating currents he has hitherto used the Schallenberger meter. The range of this meter is about 12 to 15-fold, about the same as the Schallenberger meter. If I used more delicate wheel work, the range would be greater.

I need hardly say that the perfecting of such a meter has led to innumerable experiments. Trials have also been made of a variety of other means of utilising the heat. I would not be doing my audience justice if I did not show them one other type which I have constructed, which is very simple and effective, but which has one slight defect, viz., that it is not easy to manufacture these in numbers all exactly alike. It consists of a wire conductor covered with cotton, which absorbs alcohol from a reservoir. The electric current being passed through the wire heats it and evaporates the liquid, which is condensed in a tube, where it is measured. This quantity is an exact measure of the quantity of electricity which has passed through. This instrument has not been used on commercial circuits.

Since the beginning of September, 1887, when I first exhibited the mill-wheel meter, an enormous number of patents for meters have been taken out, but I think I have described all that have as yet proved themselves to be of practical value. Each of the meters I have described has its merits, and all are doing good work in central station distribution.

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NOTES ON THE DESIGN OF ELECTRIC MOTORS.

At the last meeting of the City and Guilds of London Institute Old Students' Association, held at the Central Institution, South Kensington, on January 30, the adjourned discussion upon Mr. Albion T. Snell's paper on "The Design of Motors" was resumed.

Prof. W. E. Ayrton, F.R.S.: At the last meeting of the association we had read to us a very practical paper by a very practical man, and such a contribution from one of the old students of the City and Guilds Institute, I think, not only does great credit to this association, but is of real value to the profession which so many of the old students have, I think, wisely embraced. Mr. Snell's labours for the past few years in Mr. Immisch's factory have so thoroughly borne out the theory that was put forward some seven years ago by Prof. Perry and myself as to the difference that ought to be borne in mind in the construction of a good dynamo and a good motor, that I do not think we are likely to quarrel on side issues. At the time, that is to say in 1882, when we put forward this idea that a motor and dynamo should be constructed in a different way, I am afraid we were regarded as rather revolutionary seceders from the orthodox camp, and I suppose, in fact I feel sure, that we have not yet been received back with favour by the orthodox. It is, therefore, a great pleasure to us to find from Mr. Snell's work that henceforth the unorthodox must be regarded as the orthodox. Mr. Esson's remarks were of extreme value, because they came from another very practical man; in fact, the sort of work that these men are doing, their being able in some way or other to find time in the exigencies of commerce and the drive of business to make scientific experiments, fills me with the utmost admiration. I think it was probably due to the existence of such men in the past having been ignored, that the professors rightly earned the title they received of being "musty bookworms," and I think it will be due to the full recognition of the labours of such men that this movement of technical education is likely to lead to success. There has been, you know, considerable discussion in the newspapers and elsewhere during last year—at the British Association, for example—as to the relative value of practice and theory. It occurs to me, as it does no doubt to those here, that the discussion is rather like an imaginary quarrel between the gun and the gunpowder, as to which made the cannon-ball go to its destination. There is no doubt that the practical gun without the gunpowder would not be able to do very much. On the other hand, there is equally no doubt that the spirited mathematics of gunpowder would be wasted energy—a mere flash—a mere useless puff—had its energy not been properly controlled nor been properly directed by the practical gun. It is, in fact, by a combination of theory and practice—I may say perhaps practice and theory—that we are likely to get to success in this or in any other industrial investigation; and, therefore, if I make any remarks which appear to savour of a critical character, it is to be understood that the criticism is very far from being hostile. It will be merely suggestions I shall throw out for the purpose of enabling us to go hand in hand—practice and theory—to arrive at what we are all aiming at—that is, truth; or, put it another way, to obtain a really good motor—whatever the construction we are ultimately to adopt. It is, in fact, by theory walking hand-in-hand with practice, by the Professor co-operating with such man as Mr. Snell and Mr. Esson, Mr. Reckenzaun and Mr. Mordey, that we are likely to come to success, and not by the one fighting against the other and trying to find out whether the gunpowder or the gun makes the bullet go. Mr. Esson's remarks in regard to his experiments, I confess, were a little staggering. He brought forward statements which were to this effect—that if certain currents were sent through a machine, running at a certain speed, the E.M.F. developed was the same, whether it was worked as a dynamo or as a motor; because it is obvious that if that conclusion was universally true, then the whole theory that we propounded in 1882 as to the action of the armature in a motor—and, indeed, the theory which to a great extent has led Mr. Snell and Mr. Immisch to the success they have arrived at—would be groundless. Before the end of last meeting I was, however, able to see what was the fallacy of his conclusions. It was this. He had been experimenting on dynamos used as motors, and not on motors used as dynamos. This difference was a very important one. The armature of a good modern dynamo is, as you all perfectly well know, wound with but a few convolutions of wire, is but a weak electromagnet. Therefore, if he has succeeded in proving that the addition of a weak electromagnet to a strong electromagnet, whether with a plus or minus sign, produces but little change, I venture to think that that does not really add much to our information as to what happens in a motor. The fact that you prove that A plus a small quantity is practically equal to A minus a small quantity does not at all prove that A plus a large quantity is equal to A minus a large quantity. Immediately after the meeting, before we had left the room, I suggested to Mr. Mather that he should make the same sort of experiments that Mr. Esson had made, but not to make them on a dynamo, but on a motor, and for that purpose Mr. Mather, with the assistance of two of the students, Messrs. Drew and Wright, selected an Immisch motor, and made the experiments Mr. Esson described to you. They ran that motor both as a motor and as a dynamo. As a matter of course you run it as a motor by current supplied; and as a dynamo you have to drive it by an independent source of power. The same current was as nearly as possible maintained in the two cases, and the speed was maintained. Various currents were used for different experiments, but the same currents when the machine was used as a dynamo and when run as a motor. Owing to the field of the armature being somewhat large, there was some difficulty to get stability when run as a dynamo. Of course that was easily got over by supplying an independent source of current, so that we could work at the same part of the curve when the machine was used as a dynamo and when used as a motor. And the result, I am glad to say, from our point of view, completely disproved Mr. Esson's statements, because experiments show that when you take the Immisch motor, and run it as a motor, and afterwards as a dynamo, you get more certain conclusive results, shown in the following table:

Experiments with an Immisch Motor. Speed throughout 1,400 Revolutions per Minute.

Series A.—Armature turning WITH *the brushes.*

Amperes.	Volts at teminals.	Volts used in armature.	E.M.F. developed in armature.
	I.—Run as a motor.		
12	31	2·3	28·7
14·3	35·5	2·7	32·8
15·2	38·5	2·9	35·6
	II.—Run as a dynamo.		
12	20·5	2·3	22·8
14·3	24·4	2·7	27·1
15·2	26·9	2·9	29·8

Resistance of armature in experiments I. and II. was 0·189 ohm.

Amperes.	Volts at teminals.	Volts used in armature.	E.M.F. developed in armature.
	III.—Run as a motor.		
12	30·2	2·5	27·7
14·3	35·8	3	32·8
15·2	38	3·2	35
	IV.—Run as a dynamo.		
12	20·5	2·5	22·3
14·3	23·5	3	26·5
15·2	26·5	3·2	29·7

Resistance of armature in III. and IV. was 0·287 ohm.

Series B.—Armature turning AGAINST *the brushes.*

Amperes.	Volts at terminals.	Volts used in armature.	E.M.F. developed in armature.
	V.—Run as a motor.		
12	30·8	2·64	28·16
14·3	35·2	3·15	32·07
15·2	36·2	3·34	32·86
	VI.—Run as a dynamo.		
12	22·3	2·64	24·94
14·3	25·8	3·15	28·95
15·2	27·7	3·34	31·04

Resistance of armature in V. and VI. was 0·22 ohm.

If now we compare I., which is the most favourable when the machine was running as a motor with the brushes, with VI., which is the most favourable when the machine was running as a dynamo against the brushes, we have:

Amperes.	E.M.F. developed in armature of Motor.	Dynamo.	Difference in percentages of smaller.
12	28·7	24·94	15
14·3	32·8	28·95	13
15·2	35·6	31·04	15

This proves conclusively that there is a stronger field when the machine is used as a motor than when it is used as a dynamo. Whether it is possible to have this result, I will not attempt to discuss. Mr. Esson was rather of opinion last time that that was "physically impossible." Well, it may be a physical impossibility, but it happened in the dynamo-room below. These are the results that Mr. Mather, with the assistance of Messrs. Drew and Wright, gave me for the experiments with the Immisch motor running one way or the other. Every single result for a motor is distinctly higher than it is in the case of the dynamo. Of course, that also disposes of Mr. Esson's objection that self-induction was of no consequence. He said in mentioning some experiment when he found that $V + C R$ [reading from the *Electrical Engineer* of January 18] $= V_1 - C R$, where C was the current and R the resistance of the machine, "I conclude that the effect of self-induction might be neglected." Well, of course, that is all disposed of in exactly the same way for the same reason. He was dealing with an armature with a small number of convolutions, and not with an armature of many convolutions. If you have an armature with a small number of convolutions, the coefficient of self-induction, which depends on the square of the number of turns, and therefore increases very rapidly, is of little consequence. But that does not apply to a motor at all. There the addition of the armature field is a distinct feature in the motor, and I believe the effect of self-induction may be of considerable importance.

At the beginning of Mr. Snell's paper there are one or two statements which no doubt he will clear up by modifying the wording. He says, "It is now generally admitted that the effect of self-induction in the dynamo armature is to increase the lead, while in the motor it tends to diminish it." I am not sure whether I agree with that statement. The effect of self-induction is a twofold one. It is, of course, to diminish the current which passes with a given potential difference and given resistance. It is also to delay the current. Well, it is a little difficult to say what is the resultant effect in the particular case of a rotating armature. The two effects, you see, will somewhat oppose one another. The effect of delaying the current, no doubt, is to shift the poles round, and therefore the effect of delaying the current is to increase the lead of the dynamo, and diminish the lead of the motor. For, if you assume that there is a negative lead with a motor shifting the poles round, it will bring the line of commutation nearer to the neutral position with the motor. But if you take into account the weakening of the current due to self-induction—possibly, however, that was not what was intended—then I am not so sure that you can come to the same conclusion. It is most important to remember, when speaking of self-induction, that there are always two effects, the weakening and the retardation, and they may not always help one another. If, for example, in the case of a watt-meter used with alternate currents you take into account not merely the weakening,

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but also the retardation, as you must do, to treat the question properly, the results given in the books will be found to be completely reversed. He goes on to say Mr. Mordey has pointed out that in the generator the effects of self-induction in the armature windings are opposite to those of the Foucault currents in the core; but in the motor they tend to increase each other. There, again, it is a little complicated as to what is really the effect of self-induction. There is no doubt about this, that the Foucault currents in the core of an armature are in the same direction as the currents in the winding, and therefore, whatever effect the currents in the windings may have, there will be the same sort of effect produced by the currents in the core, and therefore there is no doubt whatever that in a dynamo the currents in the core tend to weaken the field as well as the currents in the windings. On the other hand, the currents in the core in a motor will tend to weaken the field, whereas the currents in the armature increase the field, as experiments show. So far you may say it is right; that is. currents in the core of a dynamo assist the currents in the windings of the armature, and both weaken the field. In a motor the currents in the core oppose the currents in the armature, and, while the currents in the armature tend to increase the field, the currents in the core tend to diminish the field. If, instead of speaking of the effects of self-induction, Mr. Snell had spoken of the currents in the armature windings, and of Foucault currents in the core, he would have been perfectly right. The effects of self-induction is, I confess, a little complicated. As Mr. Snell has pointed out, it is of value to short-circuit the coil in the armature of a motor when it passes the brushes, and not good to short-circuit the coil of a dynamo armature when it passes the brushes. In the Immisch motors, the coils when they pass the brushes are short-circuited, and this is of distinct value for this reason: That when you short-circuit these coils you get currents in the coil which oppose the current in the armature itself, and therefore the shifting of the field, due to the currents of the armature, is balanced to a certain extent by the current of a short-circuited coil. In a dynamo it is the opposite, because in that case both currents would be in the same direction. Practically, then, short-circuiting the coil in the armature of a motor enables you to keep the brushes in a fixed position; whereas, if you short-circuit the coil in the armature of a dynamo, it tends to make the lead increase more rapidly with the increase of current in the armature. Now, of course, one of the great objects aimed at in modern machines—dynamos and motors—is to enable you to have the brushes in fixed positions without sparking when the current in the armature is increased. That object is approached more nearly by short-circuiting the coils of a motor, and would be departed from by short-circuiting the coils in a dynamo. Mr. Snell, in fact, suggested that to me some little time ago, and I may mention that, in passing, as bearing out what I have just said about the Foucault currents. On page 60 of the *Electrical Engineer*, Mr. Snell gives an expression for the torque where he says $\left(T = \frac{Z_a N t C_a}{2\pi} \ldots\right)$ in one coil of the armature. I do not know whether in working out that formula he has used some particular method of counting the lines of force. Possibly he can tell us whether he has taken some particular number as the unit number, and not used the ordinary number in the electromagnetic system. If he has, of course there is no objection to the omission of the various constants that would enter into the formula. I do not know whether he intends that. If he does not, then I confess I do not quite see how the formula has been arrived at or how you can ignore, for example, the conversion of watts into horse-power, when you express the torque in pound-feet.

Mr. Snell: It is intended to be in C.G.S. units.

Prof. Ayrton: In C.G.S. units. I am not sure whether even in that case there would not be a constant.

Mr. Snell: I will explain it when I reply.

Prof. Ayrton: I should like to know why, on page 61, he says the field strength is to be relatively greater as the *size* of the machine is increased, and all through his paper he seems to admit that for large motors it is right to have a large field-magnet and comparatively weak armature, whereas for small motors it is right to have a comparatively strong armature and weak field-magnet. It would be very advantageous if in his reply he could point out why he is led to that consideration. Of course, he may have been led to it by commercial reasons, the expense of making large armatures, being, of course, considerable. Theoretically, I do not see why you should not have a relatively large armature for the large motor as well as for the small motor. Indeed, I made some calculations with Prof. Perry, some long time ago, and we came to the conclusion that, taking the Edison-Hopkinson machine of a certain weight (46½ cwt.), that if that machine had been constructed with much larger armature and much smaller field-magnets, it would have had a horse-power of 100 or more, whereas the actual horse-power was only 48. That is to say, taking into account what theory seemed to lead to as regards the rate at which the power should increase with the size of the machine, and starting with the power of a small motor, like that of Mr. Immisch's, we concluded that the power of the Edison-Hopkinson machine, when used as a motor, was not nearly as great as it ought to have been.

Such a result would lead one to conclude, in the absence of further evidence, that the larger machine should also have, when used as a motor, a comparatively larger armature and a smaller field-magnet. Possibly, he will be kind enough to give us some information as to why ideas change as we pass from a small motor to a large motor. Then, on page 61, the reasoning seems to be a little complex—where he speaks about the internal E.M.F. of the motor as being the brake horse-power divided by the current. Of course, that is *not* the actual E.M.F. It is a kind of imaginary E.M.F., and he takes this E.M.F., which he puts as equal to the difference of potential, at the terminals minus the current with the resistance plus Lm, where Lm is the value of the "reactions of the motor armature," but I do not know that that is the right way of treating the subject. I do not see how you can subtract from the E.M.F. in that way and hope to get right results. You certainly ought to add a term to the resistance, and subtract from C R a term in consequence of the increased resistance of the armature due to self-induction, but I do not think you ought to subtract from C R a term due to reactions of the armature. Mr. Esson, at the end of his remarks (he will, I hope, speak again this evening: I will not detain you long) speaks about the relative modes of series and shunt winding in the Manchester machine in order to produce compounding. Surely there is some mistake about that!

We have downstairs a machine which can be used in a variety of ways, about which we know everything, that is to say, we know all the details of construction from the maker, we know all the details of its action from the experiments the students have made here. The particular machine can be used as a simple shunt machine by using only shunt coils, or as a series machine by using only the series coils, or it can be used as a series machine, putting the shunt coils in parallel, or as a series machine, combining the shunt coils in parallel with the series coil, and, finally, as a compound machine. Now, in that particular machine, certainly the ampere-turns in the series winding are not equal to the ampere-turns in the shunt-winding where constant P D is being obtained. In that machine the series winding occupies one-sixth almost of the whole winding on each limb of the field-magnet. That one-sixth of the volume of the series coil has 66 convolutions, and with a current of 30 amperes, which is approaching the maximum the machine ought to produce, there are 1,980 ampere-turns in the series winding on each limb. The shunt coil contains 2,320 windings on each limb, and when this machine is compounding (for it compounds extremely well at one particular speed) the shunt coil has 1·9 ampere passing through it, so that makes 4,400 ampere-turns on each limb on the machine for the shunt winding. You have, therefore, to compare 1,980 ampere-turns series-winding with 4,400 ampere-turns shunt winding. So far, therefore, from the series-winding being equal, it is not one-half of the shunt winding. Mr. Esson further considers the necessity of using so large an amount of series winding. It is large, even if you take the numbers I have given, although not nearly so large as the one he seems to imagine. He seems to think that the reason is to weaken the effect of the current going through the armature. Is that quite right? Is that the reason you want so large an amount of series ampere-turns? Is there not a totally different reason? Is it not because you are working on so high a part of the curve of magnetisation that in order to raise the volts by only a few, which is necessary to compensate for the loss of volts required to send the current through the armature, you require a large increase in the number of ampere-turns? You see, if you are working high up on the curve of magnetisation, then to increase the volts by only, say, 10 per cent., or it may be 5 per cent., which is necessary to make up for the loss of volts in sending the current in the armature, you must have a large increase in the ampere-turns. I rather think that is the reason why you want so many ampere-turns, and not in consequence of the diminution of the field due to the armature. There is one other point. I am very glad to see Mr. Snell has used the method that was suggested in our original paper for plotting out the results, namely, plotting out the curves for $\frac{E}{N}, \frac{e}{n}$, and $\frac{B.H.P.746}{n c}$. That is practically the way we treated the subject originally, and that method is no doubt an extremely good one for finding out the behaviour of a particular machine. To plot these three curves is no doubt an extremely good method of attacking the problem. I cannot sit down without expressing the admiration which I am sure we must all feel for the labours of Mr. Snell and for his kindness in bringing his paper before us, and especially let me end by saying, as indeed I began by saying, that any remarks of a critical character that I have offered are merely made good-naturedly, and not in a hostile spirit.

Mr. Reckenzaun: I did not have the pleasure of hearing Mr. Snell's paper read, but I have carefully perused its contents. I perused the paper several times in the hope of finding some points about which I might disagree, but I was unable to find fault with the practical part of the paper. My own views, which are based upon long experience, coincide with those expressed by Mr. Snell in his excellent paper. The knowledge that there is a decided difference between the reaction of the armature, when a machine is working as a motor as compared with when working as a dynamo, dawned upon me at a very early period, especially in the early days when literature on the subject was scarce, and when the paper of Profs. Ayrton and Perry was published some seven years ago. I made that paper a kind of textbook which I have been working to ever since, more or less, and I consider Mr. Snell's paper an excellent supplement to it. On an occasion, some six years ago, I used one of my little motors of ½ h.p. capacity to work as a generator. I wanted to generate a current from a dynamo, and no dynamo being at my disposal I used a motor, and I found that the same machine when running as a dynamo required 60 per cent. more speed to produce the same E.M.F. and current. This surprised me very much at the time—in fact, I was very much astonished; and in order to ascertain whether this result was due merely to the design, I made tests of every kind of dynamo that was at my disposal, and I tried each machine as a motor and as a generator, and then I compared the results. Among those machines were samples of the Burgin, Siemens, and De Meritens, and I had the pleasure of making some of the experiments in conjunction with Mr. Kapp at the time. I thought that to pick out the heaviest of these machines, which was the Burgin, it would probably give the smallest difference in the results. This machine weighed 912lb., its resistance between the terminals, cold, was 1·021 ohm, and the resistance of the armature between the brushes was ·5 ohm; it was a series machine, and I may remark that all my experiments at that time were made with series wound machines, purposely. The

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results I obtained were as follows: with the Burgin machine, running at a practically constant speed, as a motor 1,076 revolutions, 17·8 amperes, 116·2 volts at the terminals, 2·67 e.h.p., 2·15 brake h.p.; running as a generator, 1,086 revolutions, which was as near as I could get it to the 17·8 amperes, 80·4 volts, 1·6 e.h.p. I then made another experiment by keeping the E.M.F. as constant as possible, and the current, and this will show how the speed varied. When running as a motor it was 728 revolutions, 19·4 amperes, 83·5 volts, 1·2 e.h.p., 1·46 brake h.p.; as a generator it made 1,100 revolutions, 19 amperes, 85·18 volts, 1·67 e.h.p. I calculate out this machine because it was the heaviest, and the one which had the heaviest field-magnets. I can only repeat that I agree in almost every part, at any rate, of the practical part, of Mr. Snell's paper, and therefore I cannot prolong the discussion any further, because I have no argument. I can only congratulate him and the profession at large on this very excellent paper which we have received.

Mr. E. W. Smith: Prof. Ayrton mentioned the short-circuiting the cores of the brushes. There are two arguments for it and one against it. Prof. Ayrton has given the one against it. Prof. Silvanus Thompson's favourite one for it is that you should short-circuit the coils just so long that they should get up the same current in the opposite direction, so that there should be no effects of self-induction when the coil is passed on the other side of the brush. The other argument is that the armature short-circuiting has not much effect in the dynamo because the armature field is so weak compared with the dynamo. Of course the thing that determines how long you make the short circuit is, whether you have little sparking or the effects of self-induction, or the effects of self-induction and no sparking.

Mr. G. Gumpel said: When he first heard of Mr. Snell coming forward to give some remarks on the subject of motors, he thought it the best opportunity of getting information on the most important subject that electrical engineers could bring forward. He believed that every indication pointed to the probability of makers turning their chief attention in the future to the perfecting of motors, and that if we could look into the future of electrical engineering, the next six or eight years would see a great development of the motor; that when we can once burn a cheap material—oxidised coal—at a low temperature, we shall have got over the difficulties of the problem of electric lighting. He thought that the present paper was the first that had been specially applied to the design of electric motors, except Prof. Ayrton and Perry's, seven years ago.

He agreed generally with Mr. Snell's conclusions. Nevertheless, he would be heretical, inasmuch as he proposed to attack the whole system on which those questions were dealt with. The relation between a dynamo and a motor had to be considered. He wholly disagreed with Mr. Snell's treatment of the subject. If there were no generators, but simply electricity and its applications, the question of the electric motors would be attacked altogether differently. He drew an analogy between the dynamo and the air-pump and air-compressor, with the object of showing that the one had the same elements of inefficiency as the other. Seven years ago Prof. Silvanus Thompson, in a paper read before the Society of Arts, introduced his subject with the remark that Clerk Maxwell, just before his death, being asked what was the greatest discovery in the last 25 years, replied, "The reversing of the Gramme dynamo." He (Mr. Gümpel) wrote to one of the papers—*Knowledge*—stating that Clerk Maxwell could not have said such a thing. It was built upon Lenz's law, which was published in *Poggendorf Annalen* in 1834.

Mr. Kilgour suggested that the interest on the cost of motor divided by the number of hours it was worked might be expressed in watts at the current price of electricity. Adding this ordinate to the ordinate representing e.h.p. supplied in Mr. Snell's diagram, this would tend to bring the point of maximum efficiency further to the left, and nearer to the point of maximum output. This point, he thought, might influence the construction of motors in some cases.

Dr. Walmesley: I have little to say, because all my points have been anticipated by one speaker or the other; but I congratulate the society on having such a paper brought before it. It is a great thing for the society, and I congratulate Mr. Snell upon the very admirable paper he has given us. Mr. Snell wishes that I should refer to a point as to the equation dealing with the back E.M.F. The meeting will have gathered from Prof. Ayrton, and know already, that it is not the electrical back E.M.F. Mr. Snell has explained to me that, although it so appeared in his paper, his intention was that it should not be referred to as internal E.M.F. of the armature. If that were so, of course then the efficiency of the motor will be 100 per cent., because the only way in which you can put energy into the motor is by making the current work against a back E.M.F. If, therefore, C is the current—a series motor is referred to in the question—E_m is the real back E.M.F. of the motor, and the total energy put in must be C times E_m, and if that is the brake horse-power you have a highly efficient motor. The way in which I would prefer to write the equation is as follows:

$$\text{Motor}: E_T - C R = E_m = \frac{\text{B.H.P. } 746}{C} + L_m$$

$$\text{Dynamo} \quad E_T + C R = E_d = \frac{\text{B.H.P. } 746}{C} - L_d$$

Mr. W. B. Esson: I should like to ask Prof. Ayrton a question about the Immisch motor, as to whether it was a drum armature or a ring armature?

Prof. Ayrton: A drum armature.

Mr. W. B. Esson: Yes: that seems to me to be rather important. Another question I would ask Prof. Ayrton is: When he sent the current through the machine as a dynamo, was the lead the same amount in a forward direction as it was in a back direction, when he used it as a motor? That also is very important.

Prof. Ayrton: That, and any further questions, I will answer later.

Mr. W. B. Esson: I do not know whether I am in order in saying much now, because I had my turn last time.

The **Chairman**: We shall be very glad to hear anything from you on the subject.

Prof. Ayrton: We shall be delighted to hear more from Mr. Esson, who made such excellent remarks last time.

Mr. W. B. Esson: Well, the first point is about the drum armature. Of course, in a drum armature, the saturation is much less in the core of the armature than it would be in a ring armature, and my experiments were made with a ring armature. In the paper which detailed those experiments, I put in a term for the self-induction, as the expression was meant to be a general one, and, of course, the self-induction becomes very important when you have a low degree of saturation in your armature. Prof. Ayrton, in describing his experiments, says in all cases the E.M.F. of the motor was very much higher than that of the dynamo; but I want to point out that when you take the difference of potential at the terminals of the motor, and deduct from that C R, you are not then measuring the back E.M.F. of the motor; you are sending a current through this motor, and, in doing so, you have to overcome, first, the electrical resistance, C R; secondly, the back E.M.F. of the motor itself; thirdly, the E.M.F. due to self-induction, and therefore you are measuring the E.M.F. of the motor, plus something which depends on self-induction. Come to the dynamo. When you take the difference of potential at the terminals of the dynamo, and add C R, you have not got the E.M.F. of the dynamo, but you have got the E.M.F. minus the term which depends on self-induction. I contend that Prof. Ayrton, in his experiments, has been really measuring the self-induction of the machine, and the difference which he has got—the difference in volts—is equal to twice the E.M.F. due to self-induction. That is on the supposition, mind you, that he uses the same back lead in the motor that he does forward lead in the dynamo. It is a very simple thing to measure this self-induction, and it ought to be measured, then Prof. Ayrton would know exactly how much to credit to this, and how much to credit to the strengthening or weakening of the field. Mr. Snell has added some new figures on the board, and he told me to-night before the discussion was resumed, that he had measured the back E.M.F. in a machine run as a motor and the E.M.F. in the same machine run as a dynamo, getting therefrom the value of the field as shown on the board. I would ask whether that was a drum armature.

Mr. A. T. Snell: A ring armature.

Mr. W. B. Esson: I find that it was not very highly saturated because I have worked it out in C.G.S. units, and the effective magnetism was equal only to 13,720 for the dynamo and 14,602 for the motor. There is only one thing that I have to add, and that is about the compound windings of the Manchester machine. In the dynamo downstairs, that Prof. Ayrton talks of, it may be that the series is about half the shunt. That is a very common proportion; it is the proportion which we have in the Phœnix dynamos, but, of course, the turns of the series wire depend upon a great many things. In our dynamos the series turns on the magnets have generally a fixed relation to the windings on the armature, but they depend upon the turns on the armature, upon the degree of saturation in the field, and upon the self-induction. I have measured the compensating effect, and I have also measured what is required to raise the E.M.F. of the machine. It is a very easy thing to do. You simply take the saturation curve of the machine by separately exciting it, allowing no current to flow through the armature; you mark the position of 100 volts, and see how many ampere-turns are required to raise it to 105. When you have done this you find how many ampere-turns you want on the field-magnets to bring the E.M.F. up from 100 to 105 volts with the full current flowing, and I find that in the Phœnix machine the ampere-turns required to counterbalance the weakening effect are exactly equal to the amount of ampere-turns required to raise the E.M.F.

While I was experimenting on this subject I consulted Mr. Kapp, Mr. Swinburne, Mr. Sellon, and some other of my friends, and in most cases they found that they had about the same effect. The most peculiar instance was furnished by the Victoria dynamo, for there I think the compensating turns were four times the amount required to actually raise the E.M.F. requisite for sending the current through the armature and series wire.

(To be concluded.)

COMPANIES' MEETINGS.

THE EASTERN TELEGRAPH COMPANY, LIMITED.

The thirty-third half-yearly general meeting of the Eastern Telegraph Company, Limited, was held on Thursday, Jan. 24th, at Winchester House, Old Broad-street.

Sir John Pender presided, and, in moving the adoption of the report, stated that the revenue for the six months ended September last had been £310,104, being an increase of £18,839 as compared with the revenue for the corresponding period of 1887. Their holding of shares in the Eastern and South African Telegraph Company had given them an increase of £7,800, the dividend having been at the rate of 12 per cent. per annum as against 8 per cent. last year; and their general traffic, chiefly South African and South American, had given them £10,531 more. The working expenses for the half-year had been

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£83,332, or £3,396 more. The number of their foreign staff had been increased in order to work the triplicate cable from Porthcurnow to Malta, and extension to Zante, and the duplexing of the same. They had also opened a new station at Cadiz, having put that place in telegraphic connection with Villa Real and Gibraltar. The laying of the new cable from Porthcurnow to Malta and Zante, besides giving the Company greater security and rapidity of working, had diverted to their system a large part of the Greek and Turkish traffic which formerly went *viâ* the Continent. A greater number of messages had been carried in the past half-year than in the corresponding period of the previous year, and the work to be performed by their staff increased year by year. They had carried £5,000 to their reserve fund for maintenance of ships against £4,000 in the previous half year, thus accounting for £1,000 of the total increase in the working expenses. The repairs to cables had cost them £43,075, or £8,973 more. That was always an uncertain item in their accounts. The ships had been busily employed in maintaining the Company's system in a state of efficiency. The increase under this head was in the value of the new cable laid in, the total length being 130 miles against 38 miles in the corresponding period of 1887. A reference to the reserve fund would show that they had applied over £13,000 in reduction of capital expenditure, or in other words, although they had spent over £13,000 in extending and improving their system, the capital expenditure remained at practically the same figure as last time. The 6 per cent. debentures of the Direct Spanish Telegraph Company had been transferred to their reserve fund investments, which stood at £315,494, the total reserves of the Company amounting, after deductions, to £355,676. They paid the usual interim dividend at the rate of 5 per cent. per annum; and after providing for interest on debentures, debenture stock, and preference shares, they were able to carry £36,616 forward, or £7,219 more than in the corresponding period of 1887. When they met six months hence he hoped to have the pleasure of announcing the completion of their West Coast of Africa cable—a work which would not be finished an hour too soon. An enormous traffic was now being carried to the Cape and the Transvaal in connection with the gold speculations, and any interruption to the present cable would be disastrous. With the other cable completed, he fully believed they would be able to meet all the telegraphic requirements of the public. Their system was working thoroughly well, but to keep it in a state of entire efficiency a vast amount of work had to be performed by their ships. Being in the neighbourhood of Suakin, their vessels had given every possible assistance to the British Government while the Egyptian and English troops were in action there, and their help had been thoroughly appreciated. They had maintained their system in a thoroughly efficient state, but what he had told them showed the necessity of duplexing and duplicating the system, without which they could not possibly have carried out the work they had done.

The **Marquis of Tweeddale** seconded the motion.

In reply to remarks by **Captain Goodsall**,

The **Chairman** stated that that gentleman had left the Company's service. The paper mentioned by Captain Goodsall was established by Sir James Anderson and one or two other gentlemen interested in telegraphy, entirely for the benefit of the great system with which they were so closely connected, for the purpose of giving the best scientific opinions upon questions relating to cables. They had never taken one shilling of profit from the paper. It was true that occasionally when any important negotiations were going on he had been abroad, and in connection with such purposes he had used the Company's ships. He had found that negotiations had been far more successful when carried out in person instead of by correspondence. But for their coming into frequent communication with the Great Powers of Europe and elsewhere, he was confident that the Company would not now be occupying the high position it did. Such "excursions" as those referred to by Captain Goodsall were no benefit to himself or Sir James Anderson, while, on the other hand, they involved some sacrifice.

The motion was carried, and resolutions were afterwards passed re-electing the retiring Directors and Auditors.

DIRECT UNITED STATES CABLE COMPANY.

The twenty-third ordinary general meeting of the Direct United States Cable Company, Limited, was held on Friday last, at Winchester House, Old Broad-street.

Sir John Pender presided, and in moving the adoption of the report stated that the revenue for the half-year to December 31, after deducting out-payments, had been £34,188. The working and other expenses, including income tax, but exclusive of the cost of repairs, had been £16,476, leaving a balance of £17,712 as the net profit of the half year. Adding the sum of £6,071 transferred from the reserve fund account for dividend purposes to June 30 (that was, to the end of their last financial year), there was a total of £23,783, out of which two dividends of 2s. each had been paid for the quarters ended June 30 and September 30, leaving a balance of £11,641 on the revenue account. A further interim dividend of 3s. 6d. per share for the quarter ended December 31, being at the rate of 3¼ per cent. per annum, had been declared, and the dividend warrants would be posted that evening. There would then remain a balance of £1,017 to be carried forward. The revenue for the half-year—which included only four months at the shilling rate, the 6d. tariff having been in force up to the end of August—showed an increase of £11,185 over that of the corresponding period of 1887, but no reliable comparison was afforded by these figures, because the 6d. tariff was in force throughout the whole of the six months to December, 1887. The shilling tariff, however, had brought about some reduction in the volume of the traffic, as was naturally to be expected, but the earnings so far had been fairly augmented. The reserve fund account, after being credited with the interest on the investments and the profit on securities realised, and being debited with the outlay on the removal to Halifax and the cost of deep-sea repairs, now stood at £239,206. The special expenditure on the removal, and the deep-sea repairs, ought to be recouped to the reserve fund as soon as convenient. The investments continued, as heretofore, to be worth considerably more than they were stated at in the balance-sheet. With reference to the change in the rate, they had so far not been disappointed in the shilling tariff, though they did not get enough from it to pay a fair dividend. He hoped, however, that people who used the system—and the commerce of the world was now carried on more or less by submarine telegraphy—would get accustomed to the extra sixpence a word, and that the traffic would then go on increasing. They were giving the telegraphing public a fair trial at a very cheap rate, and he hoped that no alteration would be necessary in the future.

Mr. William Ford seconded the motion.

In reply to the remarks of **Mr. Jackson** and **Mr. Guesdon**,

The **Chairman** stated that they did invite tenders for the repair of the cable. They were submitted to their consulting engineers, who reported as to the tender which they ought to accept, and which they did accept There was no comparision between the nature of their late repairs—constituting, perhaps, the most important repairs ever made in a submarine cable—and the ordinary repairs of the short cables.

The motion was adopted.

METROPOLITAN ELECTRIC SUPPLY COMPANY.

An extraordinary general meeting of the Metropolitan Electric Supply Company, Limited, was held on Friday at the offices, Winchester House, Old Broad-street, Sir John Pender in the chair, to confirm the resolution passed at the meeting on the 8th inst., for altering certain clauses of the articles of association.

On the motion of the **Chairman**, seconded by **Mr. J. C. Parkinson**, the resolution was confirmed.

The **Chairman** afterwards stated that they were going on as quickly as they could with their installations. They had one working, and two others were in course of construction. His impression was that they would have more demands on them than they could supply for some time, but there would be no want of energy on their part to meet requirements.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts for the week ended January 25 amounted to £5,435.

Dissolution of Partnership.—Messrs. Rowbottom and Godwin, electrical engineers, &c., of Derby, have dissolved partnership.

Western and Brazilian Telegraph Company.—The receipts of this Company, after deducting the "fifth" payable to the London Platino-Brazilian Company, were £4,550.

Change of Address.—The London office of Messrs. J. G. Statter and Co., Limited, of Alliance Engineering Co., West Drayton, is now at Princes Mansions, 68, Victoria-street, Westminster.

Great Northern Telegraph Company.—Messrs. C. J. Hambro and Son announce the numbers of the Great Northern Telegraph Company's debentures of 1883 (series B) drawn for payment on March 1.

Cuba Submarine Telegraph Company, Limited.—In their report for the half-year ending December 31, this Company state that the gross receipts (including the balance brought forward) amounted to £21,904, and the available balance to £15,508, of which £4,000 has been added to the reserve, increasing that fund to £84,000. The dividend on the preference shares will absorb £3,000, and the Directors recommend a dividend on the ordinary shares at the rate of 9 per cent. per annum, tax free, £1,308 being carried forward.

National Telephone Company, Limited.—The accounts of this Company, made up to December 31, show a gross revenue of £117,726, as compared with £99,563, and the Directors have declared a dividend for the six months ending December 31 last at the rate of 6 per cent. per annum on the first and second preference shares, and an interim dividend at the rate of 4 per cent. per annum (being at the same rate as for the corresponding period) on the ordinary shares, carrying forward £10,399, of which £3,500 is set aside against an outstanding claim. The unaccrued revenue carried forward amounts to £54,385, as against £45,826.

Anglo-American Telegraph Company.—The report of this Company states that the total receipts from the 1st of July to the 31st of December, including the estimated balance of £390 brought forward, are estimated at £131,186, which is, however subject to revision upon settlement of the accounts with the Paris-New York Telegraph Company. The traffic receipts show an increase of £35,352; the total expenses, including repair of cables, etc., amounted to £51,110. Interim dividends of 7s. 6d. per cent. on the ordinary and 15s. per cent on the preferred stocks were paid, and the Directors recommend a final dividend of 15s. per cent. on the ordinary and £1. 10s. per cent. on the preferred stocks, making a total distribution for the year of £1. 12s. 6d. and £3. 5s. respectively, leaving an estimated balance of £1,325 to be carried forward.

German Union Telegraph Trust.—The report of the Directors of the German Union Telegraph and Trust Company for the period ending January 25, 1889—their final report—states that the total receipts during the time amount to £754, which, with a balance of £156 brought forward from the last account, make a total of £910.

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The expenses for the same period amount to £909. Of this sum £750 is provided by the German Union Company of Berlin. The balance will be handed over to the liquidators. On January 22 an extraordinary general meeting of the Company was held, and voluntary liquidation was resolved upon. The liquidators will have the charge of distributing the assets receivable from Berlin in repayment of capital and interest. A first return of £7. 7s. 6d. per share will be made forthwith, and the balance at the end of April, or in the beginning of May. The liquidators now retire, and the liquidation will be made with all possible despatch.

City of London and Southwark Subway Company.—The report of the Directors of this Company states that, since the date of the last report, continual progress has been made with the underground work throughout the whole line, and so rapidly has it proceeded that in about three months from the present time it is expected that the tunnels—from King William-street to Kennington Oval, a distance of about 2½ miles—will be completed. The construction of the stations is also being actively carried on. The main underground works at the King William-street and Great Dover-street stations are nearly completed, and those at the other four stations are progressing favourably. During the last half-year over 3,800 yards of tunnelling have been completed, a speed unparalleled in work of a similar character. In accordance with resolutions passed by the shareholders at the last half-yearly meeting, the Directors have devoted a large amount of attention to the question of the best method of electrical haulage, suitable for efficiently working the traffic upon this line, and they invited proposals from several of the chief electrical manufacturers. After a very exhaustive examination into the details of the several different proposals, the Directors, acting under the advice of the Company's engineers, and aided by the valuable assistance of Mr. C. E. Spagnoletti, an experienced electrical engineer, have entered into a contract for the installation of the necessary machinery and plant with the well-known engineers, Messrs. Mather and Platt, of Manchester, the electrical department of whose business is under the immediate direction of Dr. Edward Hopkinson, who has had exceptional experience in electric traction. It is with much pleasure that the Directors are enabled to report the satisfactory conclusion of their investigations upon this most important subject. The contractors have undertaken to provide the power necessary to run a three minutes' service from each station at a greater average speed than that now attained on the Inner Circle of the Metropolitan Railways, and they also guarantee for a period of two years the cost per train mile at a considerably lower rate than if steam locomotives were used. The Directors have the fullest confidence that these provisions will be duly carried out and will result in the establishment of a system of underground conveyance for the metropolis of an exceptionally convenient character, and worked at such a cost as will give a satisfactory return to the shareholders. The electrical power provided includes also the lighting of the trains and stations. The Company have now purchased all the land and property required for the construction of the works, and have also acquired a piece of land exceeding 1½ acres in extent at Stockwell on which the machinery for working the line, as well as the carriage sheds and workshops can be conveniently erected. The Directors who retire by rotation are Messrs. Sampson Hanbury and C. G. Mott, who are eligible for re-election. The auditors likewise offer themselves for re-election.

PROVISIONAL PATENTS, 1889.

JANUARY 21.

1056. **Improved electrical storage battery.** Thomas Pease, 3, Kimberley-street, Liverpool.

1057. **Improvements in electric date and time hand stamps.** Charles Adams-Randall, 15, Montpelier-square, Brompton, London.

1058. **Improved phonographic system and apparatus for recording and reproducing articulate speech and other sounds.** Charles Adams-Randall, 15, Montpelier-square, Brompton, London.

1101. **Improvements in and relating to underground mains for electric conductors.** William Lowrie and Charles James Hall, 433, Strand, London, W.C.

1102. **Improvements in or relating to safety fuses and boxes therefor.** William Lowrie and Charles James Hall, 433, Strand, London, W.C.

1103. **Improved system of distributing pipes, or conduits, for containing the supply conductors for electric lighting.** William Lowrie and Charles James Hall, 433, Strand, London, W.C. (Complete specification.)

1112. **Improvements in simultaneous telephony and telegraphy.** Eugene Gwosdeff, 6, Bream's-buildings, London. (Complete specification.)

1113. **Improvements in long-distance telephony.** Eugene Gwosdeff, 6, Bream's-buildings, London. (Complete specification.)

JANUARY 22.

1118. **Improvements in apparatus for automatically switching loop circuits out of or into the main electric circuits.** Elmer Ambrose Sperry, 1, Quality-court, Chancery-lane, W.C. (Complete specification.)

1162. **Improvements in and relating to electric governors for steam or other motive-power engines.** Rankin Kennedy, 96, Buchanan-street, Glasgow. (Complete specification.)

1166. **Improved method of, and means for, testing the insulation of electric conductors.** William Lowrie and Charles James Hall, 433, Strand, London, W.C.

1167. **Improvements in and relating to switches and switch connections for electric circuits.** William Lowrie and Charles James Hall, 433, Strand, London, W.C.

1168. **Improvements in electric current switches.** William Lowrie and Charles James Hall, 433, Strand, London, W.C.

1169. **An automatic electrical machine for the delivery of prepaid articles.** George Evan Rutter, 26, Parkholme-road, Dalston, London, N.

1190. **Improved means in connection with electric current transformers for regulating the electro motive force in the working circuit.** Laurence, Paris, and Scott, Limited, and William Harding Scott, 47, Lincoln's-inn-fields, London.

JANUARY 23.

1216. **Automatic contact maker and breaker for electrical circuits.** George Edwin Fletcher, 93, Chatham-street, Edgeley, Stockport.

1229. **Improvements in adjustable suspending devices for electric incandescence lamps.** William Robert Rawlings and John Joseph Rawlings, 70, Market-street, Manchester.

1236. **Improvements in underground conduits or channels for electrical conductors.** Benjamin Verity, 55 and 56, Chancery-lane, London.

JANUARY 24.

1311. **Improvements in raising, and lowering, and extending, applicable to table pillars, table lamps, electric pillars, and to other purposes.** Harry Christie Harrold, Robert Jenkins, and Samuel Johnson, 30 and 31, St. Swithin's-lane, London.

1313. **Improvements in bleaching paper pulp and vegetable fibres by electrolysis.** Emile Marie Hippolyte Andreoli, 62, Loughborough-park, Brixton, S.W., Surrey. (Complete specification.)

1341. **An improved electrical indicator.** Charles Wells, 22, Southampton-buildings, Chancery-lane, W.C., Middlesex.

1343. **Improvements in instruments for measuring electricity.** Francis Henry Nalder, Herbert Nalder, Charles William Scott Crawley, and Alfred Soames, 55 and 56, Chancery-lane, London. (Complete specification.)

JANUARY 25.

1358. **Improvements in electrical coin-counting, valueing, and checking machines.** James Gilbert Cumming, 7, Union-street, Edinburgh.

1401. **Improved mode of generating electricity by dynamo-electric machines.** Isaac Tillman Dyer, Peter Fish, and Rebecca Charlotte Fish, 76, Chancery-lane, London, W.C. (Complete specification.)

1420. **Improvements in secondary batteries.** Frank King, 47, Lincoln's-inn-fields, London.

1421. **New and useful improvements in voltaic electric belts employed as medicinal agents.** George Allan Sykes, 30, Romberg-road, Upper Tooting, London, S.W. (Complete specification.)

JANUARY 26.

1454. **Electric meters.** Henry Francis Joel, 44, Lavender-grove, Dalston, London, E.

1456. **Improvements in electric traction.** Vittorio Giovanni Lironi, Walnut Tree House, High-road, Leytonstone, Essex.

1460. **Improvements in secondary battery plates, elements, or supports.** John Scudamore Sellon, 47, Lincoln's-inn-fields, London.

SPECIFICATIONS PUBLISHED.

1888.

2707. **Friction dynamometers.** Coupe. 8d.
2772. **Electrical safety appliances.** Hedges. 8d.
2933. **Regulating dynamos.** Haddan. (Hill.) 8d.
3223. **Secondary batteries.** Kingsland. 6d.
17,008. **Dynamo machines.** Schiödt. 6d.
17,063. **Electric spray-preducing apparatus.** Huguet. 6d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	4
12 Feb.	2/0	— fully paid	5	5
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	19
......	...	House-to-House	4½	—
30 May	2½%	Oriental Telephone	11	½
26 April	4/0	Reuter's	8	7¼
......	...	Swan United	3½	2½
12 July	12/0	Telegraph Construction ...	12	42¾
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	13

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NOTES.

Moscow.—A large central station is being opened in Moscow.

Mysore.—An electrician from England is now at Mysore fitting up electric light in the Maharajah's palace.

Arc Lamps.—The Thomson-Houston Company sold 18,500 arc lamps during the last year to all parts of the world.

Julien Company.—The Julien Company will shortly have 12 storage cars running on the Fourth-avenue road, New York.

Edison Transformer.—Edison is said to be at work on a transformer which is to be the ideal method of distributing energy over large areas.

Strand.—An influential memorial has been presented to the Vestry of St. Martin's-in-the-Fields urging them to light the Strand with electric light.

Royal Institution.—On Friday, February 8, at 9 p.m., the Royal Institution will meet to hear Sir William Thomson on "Electrostatic Measurement."

Companies in 1888.—The *Investors' Guardian* gives the following statistics of electrical companies formed in 1888: Electric, £3,026,500; Telephone, £20,240,000.

Smoking Concert.—The fourth smoking concert of the City Guilds Old Students will take place at the Manchester Hotel, Aldersgate-street, on Saturday, February 23, at 7.30 p.m.

Printing by Electricity.—The presses of the *Iowa State Register* of Des Moines, U.S., are worked by electricity. The editor says it is a good, safe and cheap power for the purpose.

National Telephone Company.—The nomination of Mr. J. B. Morgan, managing director of the United Telephone Company, has been withdrawn from the Board of the National Telephone Company.

Electric Launch for the Sultan.—A launch, with a swan's-neck prow, is now being built at Richmond for the Sultan, which will be driven by electricity. It is to be delivered at Constantinople in April.

Kensington.—Representatives of the several electric light companies met the Kensington Vestry at a special meeting on Wednesday to explain their systems. The report of the committee was adopted, one of the chief provisions being that no overhead wires were to be used.

Arc Lighting in Paris.—Paris will be brilliant with arc lights during the present year. A sum of 200,000f. has been voted for lighting the Avenue de l'Opera and the principal boulevards, from the Madeleine to the Boulevarde de Sebastopol, with arc lamps during the period of the Exhibition.

Windsor Castle.—After several trials, it has at length been decided to use the electric light at Windsor Castle. The machinery at the palace is now in working order, and a portion of the corridor will, it is understood, be illuminated by a series of incandescent lamps on the return of the Court from Osborne.

Spanish Electrical Journal.—New electrical papers are springing up as the field increases, and the late exhibition in Barcelona seems productive of result in this direction. We have this week to acknowledge the receipt of a copy of *Anales de la Electricidad*, published in Barcelona, and devoted to electrical subjects.

Wolverhampton.—We hear that a company is being formed for supplying electric light in Wolverhampton. The gentlemen who are promoting the scheme, it is said, hold positions of considerable influence in the town and district. It is understood that the necessary plant will be supplied by Messrs. Elwell-Parker.

Speed on Electric Railways.—The cars on the Sprague railway with overhead wire at St. Joseph, Mo., have sometimes been run at as high a speed as 25 miles an hour. This is approximating to the speed of a Continental railway express, so that we may evidently soon hope to see real railways work electrically.

Engines at the Louvre.—The Paris authorities have just awoke to the danger likely to occur from the engines and furnaces for the electric light which have been allowed to be erected in immediate proximity to the valuable collection of pictures in the Louvre. The whole of the engines are now ordered to be removed.

Folkestone and Dover Telephone.—The business done over the wire of the South of England Telephone Company between Folkestone and Dover proves how very great a need there existed for cheap and rapid communication. Since April last, when the line was opened, no less than 54,165 messages were transmitted up to the close of last year.

Meters Wanted for Bradford.—The installation at Bradford now approaching completion, the Corporation desire to adopt some reliable meter for measuring the sale of their currents. In another column will be found an advertisement asking companies or persons who have such meters for disposal to communicate with Mr. J. N. Shoolbred, the engineer to the Corporation.

Institution of Electrical Engineers.—The next meeting of the Institution will be on February 14, at 8 p.m., when the adjourned discussion of Prof. Jamieson's paper on "Insulation Resistance of Electric Lighting Plants" will be concluded. A paper will be read "On Certain Phenomena Connected with Imperfect Earth on Telegraph Circuits," by A. E. Kennelly, associate.

Bingley Hall Exhibition.—Our readers will see from the advertisement that the promoters of the Electrical Exhibition at Bingley Hall, Birmingham, are pressing forward with their arrangements. The whole of the power is intended to be supplied electrically, and all departments of electric industry will be represented. The committee are now prepared to receive applications from intending exhibitors.

Self-Exciting Alternating Dynamos. — Both Thomson-Houston and Ganz and Co. now make alternate-current dynamos which are self exciting. The means adopted is simply that one of the armature coils is compound-wound and connected to a separate small commutator on the shaft which commutes the current into one direction; the current from this is then used to excite the field-magnets of the machine in the ordinary way.

Gas v. Electricity.—The Imperial Continental Gas Association of Vienna, while adding to their power of light supply by the central electric light station at Schenkenstrasse, are also, it appears, increasing their gas supply by putting down a new gas works. The gasholder is to be, moreover, the largest upon the Continent. This looks as

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if the Vienna company did not think their gas business was likely to ultimately suffer by the electric competition.

Birmingham.—At a meeting of the City Council on Tuesday the General Purpose Committee reported that they had considered Messrs. Chamberlain and Hookham's application for a provisional order for electric lighting, and recommended the Council to withhold consent except for a restricted area. An amendment was proposed by Alderman Powell Williams, M.P., that the Council should consent to the application for an order to light the whole of the city. Ultimately the amendment was withdrawn, and the report agreed to without a division.

Oporto.—Tenders were to be received by the Municipal Board of Oporto for lighting the town with gas up to the 7th inst. Parties tendering will have to deposit a sum of 10,000 milreis, which is to be raised to 50,000 milreis when the contract is finally adjudicated. The municipality engages to use only gas supplied by concessionaires during fifteen years, and to give them the preference, if after that period it should be decided to introduce electric lighting. At the expiration of the concession all the plant is to be delivered gratuitously to the municipality.

Small Portable Testing Set.—A new and very light portable set, designed by F. B. Badt, and manufactured by the Western Electric Company, Chicago, is described and illustrated in the *Western Electrician.* It is a little under six inches long by four deep and three inches wide, over all, and weighs 1lb. 15oz., including cell and galvanometer. The box contains a small dry cell, a detector galvanometer of 200 ohms resistance, contact key, binding posts and wires. The small weight and the use of a dry cell allow it to be carried in the pocket or tool bag, and will make this set very useful to linemen.

Australasian Electric Light Company.—The reconstruction of the Australasian Company has been attempted on terms that give call for little more expenditure (4s. 3d. per share) to that of winding up, with a prospect in the former case of possibility of a profit. The patents held by the company will consist of those of Swan-Edison, Elwell-Parker, Zipernowski-Deri, and others, and give a practical monopoly of electrical business on any large scale in the Australasian colonies. Controlling these patents in the colony, if this company cannot do the work, they maintain at least no one else can do so without their con sent.

A New Secondary Couple.—We hear from a gentleman who has had some experience with lead accumulators, and has been experimenting lately with other forms, that he has discovered a new secondary couple, giving very good results. The charge of one hour was discharged in 20 minutes after only three or four chargings; and the E.M.F. on open circuit is given as 2·60 volts. The elements are metallic, but not lead, and, as far as the inventor knows, quite original. The experiment is only upon a very small scale, but if any of our readers are interested in the matter we shall be happy to put them into communication with the experimenter.

Swinton Electric Bells.—Mr. Campbell Swinton, who has lately moved into new offices next door to Drake and Gorham, 2, Princes-mansions, has some new and very useful modifications of his electromagnetic bells. He showed us the other day a very compact set, enclosed in polished box, with a single handle, with press-knob projecting from the interior, which rings one single, clear stroke of the bell to every depression of the knob. This bell, without battery or solution to get out of order, should prove extremely useful to stand on an office table and ring in the next room, or to a factory, and also for railway or ship signalling, and for all requirements of this description.

Electric Date Stamp.—An invention for affixing the exact time and date to important documents, telegrams, etc., is being brought out by the Electric Date and Time Stamp Company, Limited, of 19, St. Swithin's-lane, E.C. The box contains battery and clock, and a stamp with the name of the user and any other lettering desired, and has a space for the date and time, which is automatically altered by electricity by the motion of the clock. The stamp is favourably reported upon by Mr. C. P. Spagnoletti and Mr. D. K. Clark, M.I.C.E., reports from whom can be seen at the offices of the company, where the stamp can also be seen in operation. The apparatus is installed and kept in working order on yearly rental.

Lugo's Storage Battery.—Dr. Lugo, of Chicago, has invented a new form of storage battery, in which the oxygen and hydrogen gases evolved are stored mechanically without chemical combination. The electrodes are of finely divided or allotropic lead, each atom of which is coated or completely covered with soft or spongy copper. The material is, therefore, not oxidisable under influence of the charging current. It is packed round conducting plates and immersed in electrolytic solution. In charging, the gases accumulate around the atoms, which act as nuclei. It appears to be an actual storage battery, in the sense that something is stored—namely, the gases. It is claimed as a new departure in the manufacture of storage cells.

A Fever Alarm Thermometer.—Mr. Wilberforce Arnold, J.P., fellow of the Medical Society of London, sends the following to the *Pall Mall Gazette* from Belfast: "A watch-shaped, or other suitable clinical thermometer, could be fixed in the axilla, etc., as easily as the smallest splint. Electrical connections should lead to the sounding of an alarm-bell in some suitable nurse's or other apartment in hospitals and sick homes, giving instant warning to the watchers of any dangerous rise or fall in the patient's temperature, and the calling of physicians or other help without an instant's loss of invaluable time. This would in every country and in all climates be the means of saving many lives every year and throughout all time."

Swansea.—The question of electric lighting is still agitating Swansea, and it has been advocated that the Corporation should purchase the existing gas works, and erect an electric light plant on the same site, so that the Corporation could supply from one station and under one control either gas or electricity. It is suggested that, no doubt, much of the engine-power at present in use by the gas company could be used for both purposes. The Corporation propose, it is said, to use a site cleared at great expense for artisans' dwellings, and the question is raised whether the Corporation would be justified in using such valuable land. If the site of the gas works were used, both gas and electricity might be supplied from the same site, as in the manner of the Vienna Gas Association.

"Everybody's Pocket Cyclopædia."—A third edition of 50,000 of *Everybody's Pocket Cyclopædia of Things Worth Knowing,* price 6d., has been issued by Messrs. Saxon and Co., Bouverie-street, a copy of which has been sent to us. It contains an immense amount of useful

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memoranda and information compressed in small size, and seems to be most eagerly bought up. In the last edition sixteen pages of nicely-printed small coloured maps of the world are added. Some interesting telegraph statistics of the world are given, but we might suggest that in a further edition some really reliable and useful, but popular information with regard to electric lighting—the influx of which into "everybody's" home is now imminent—might prove more interesting to the public generally than statistics of telegraphs.

Islington.—A special meeting of the St. Luke's (Islington) Vestry was held on Tuesday afternoon, under the presidency of Mr. Churchwarden Blake, for the purpose of considering the terms of the draft provisional order of the London Electric Light Corporation. The Parliamentary and Improvement Committee submitted recommendations favouring the scheme upon certain conditions being observed. They were that the company should fully satisfy the Vestry as to its competency to undertake the work they proposed to carry out; and they should deposit a certain sum of money with the Vestry to provide for the reinstatement of any of the foot or road ways which might be opened and not properly relaid. The committee also advised that steps should be taken to secure distributing mains being laid at the sides of streets. The adoption of the foregoing recommendations was agreed to unanimously.

Exhibition of Meteorological Instruments.—The Council of the Royal Meteorological Society have arranged to hold at 25, Great George-street, Westminster (by permission of the Council of the Institution of Civil Engineers), on March 19th to 22nd inst., an exhibition of instruments connected with atmospheric physics invented during the last ten years, especially those used for actinic and solar radiation observations. The Exhibition Committee invite the co-operation of those interested, as they are anxious to obtain as large a collection as possible of such instruments, etc. New meteorological instruments or apparatus invented or first constructed since last March will also be shown, as well as photographs and drawings possessing meteorological interest. Lists of the articles intended to be contributed, with space required, should be sent in not later than March 1st to Mr. William Marriott, 30, Great George-street, Westminster.

Certificates of the School of Electrical Engineering.—In consequence of the recent reorganisation of the advanced instruction of the School of Electrical Engineers, Princes-street, Hanover-square, which is now under the charge of Mr. Charles Capito, M.I.M.E., the managers recently requested Mr. Gisbert Kapp to undertake the examination of the advanced class. One day was devoted by him to an examination in practical work, such as engine-running, boiler-firing, dynamo and lamp management, joint-making, etc., and a second to papers in mechanical and electrical engineering. Out of seven students examined, three were awarded the certificate of the school, Messrs. Hawkins, Rowlett, and Graves, the average percentage of marks gained by them being respectively 87·3, 78·8, and 65·8. A minimum of 70 per cent. in the practical work, and 60 per cent. in the two papers is a necessary condition of obtaining the certificate. As the result of former examinations, Mr. Fletcher has also recently gained the certificate.

Albion T. Snell on Motors.—M. Hospitalier, in *L'Electricien*, gives some attention to the very interesting paper written by Mr. Snell for the Old Students' Association, intending, he says, to give a complete *résumé* of this paper, "for in this work are found indications on the construction of dynamos not less useful than those which fill the work of Mr. Gisbert Kapp, on the construction of dynamos. Unfortunately, however," M. Hospitalier remarks, "scorning the C.G.S. system and the metric system (as all good Englishmen do, with few exceptions), Mr. Snell gives all the factors of his calculations in inches, pounds, and horse-power: we shall be therefore obliged to do once again, as we have already done for Mr. Kapp to a whole series of complex calculations—to reduce the calculations of the author to C.G.S. units, and the practical units derived therefrom. We trust the author will pardon us rendering more international a study which, under the original form, seems to be specially reserved for John Bull and Cousin Jonathan."

The Centenary of Ohm.—In view of the near approach of the hundredth anniversary of the birth of George Simon Ohm, which took place on March 16, 1789, a meeting was held last week in the meeting room of the Royal Society, under the presidency of the Right Hon. Lord Rayleigh, secretary of the Royal Society, for the purpose of appointing a committee to co-operate with the committee formed in Germany to promote the erection in Munich of a statue to the great physicist, to whom the science of acoustics owes no less than does that of electricity. In the course of the meeting the following gentlemen were selected to act on the English committee: Sir F. Abel, D. Atkinson, Mr. Vernon Boys, Mr. Conrad Cooke, Professors Ewing, Fitzgerald, Fleming, G. Carey Foster, Mr. Glazebrook, Prof. D. E. Hughes, Mr. Norman Lockyer, Professors Hugo Müller, John Perry, Mr. W. H. Preece, Lord Rayleigh, Professors Reinold Rücker, Stokes (President of the Royal Society), Mr. Swinburne, Sir William Thomson, and Prof. S. P. Thompson. Lord Rayleigh was elected president, Prof. Hugo Müller treasurer; and Prof. G. Carey Foster, of University College, London, and Prof. John Perry, of the Finsbury Technical College, undertook to perform the duties of secretaries, and to receive subscriptions.

Telephone in the West of England.—The trunk telephone line between Cheltenham and Gloucester has been formally opened by the Western Counties and South Wales Telephone Company, and telephonic communication has thereby been established between Cheltenham and Gloucester, Bristol, Bath, and other large towns in the West and South of England, and also with Cardiff and other provincial towns in South Wales. In Swansea the fullest and largest benefits of telephony are within reach of people. Anyone can go to the company's call offices, and can hold communication, on payment of a fee of 2d., with any subscriber who may be attached. Not only so, but, on arrangement beforehand—that is to say, by sending a halfpenny post-card—two persons, say one in Newport and another in Swansea, can arrange to meet at a certain fixed hour at one of the call offices in each town, and there, for 2d. each, they can hold a long conversation. The same arrangement can be brought about within an hour by the despatch of a sixpenny telegram. These facilities will evidently lead to much business advantage when they become generally known. The local telephone company now goes further, and is prepared to issue to all subscribers to the Telephone Exchange a free pass (on payment of a returnable deposit of

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5s.) which will enable the holder to make use of any of these public call offices without payment of the 2d. fee. Telephone facilities are wonderfully increasing in the provinces.

Lambeth.—A report was read from the Electric Lighting Committee with respect to the applications made by the London Electric Supply Corporation and the Metropolitan Electric Supply Company for provisional orders for Lambeth under the Electric Lighting Acts. The committee recommended the Vestry to oppose both the applications, with the view of obtaining from one or other of such companies, or from some other company or contractor, such protective clauses and provisions as the committee, under the advice of the officers of the Vestry, might consider necessary in the interests of the parish. Mr. Andrew, in moving the adoption of the report, said the committee were ready to do everything to further the progress of the electric light, but at the same time they desired to prevent the creation of another monopoly. Mr. Penman asked whether it would not be better for the Vestry to apply for a license and then farm it out to some company. Mr. Andrew replied that the Board of Trade would not grant a license unless they were assured that the Vestry intended to carry it out. It was suggested that clauses should be inserted as follows: (*a*) "That the company should be bound to lay down mains and supply electricity in certain trunk streets within a definite time, to be settled by the order, and in side streets when required either by the Vestry or by a specified number of owners or occupiers in such streets, and that on the breach by the company of this condition the order should be cancelled; (*b*) that the cost of laying all mains in the public streets should be borne by the company; and (*c*) that all wires should be laid underground unless with the consent of the Vestry." After some discussion the Vestry adopted the committee's recommendations.

Prize Competition for Measuring Instruments. A German electrician, Herr F. Zöpke, has addressed a circular to his clients, says *Industries*, calling their attention to the importance of prolonging the life of lamps in installations by carefully limiting the pressure to that value for which the lamps are intended. He suggests that overrunning may occasionally be due to carelessness on the part of the driver, but is more often caused by wrong indication of the voltmeter. To detect a change in the calibration of instruments, he suggests that every installation should be provided with one standard voltmeter, to be carefully kept in the owner's office, and used occasionally for controlling the engine-room voltmeter, or that a standard voltmeter, provided with an alarm bell, which will ring when the right pressure is exceeded, should be placed in some convenient place. He offers such standard instruments at an annual rental of £1 and £2 respectively. As, however, the adoption of his suggestion would only mitigate the evil, by facilitating the detection of errors in the ordinary instruments, but not completely cure it, he has offered a prize of £50 for a better solution of this question. For this purpose Herr F. Zöpke has requested the Berlin Technical College to issue the following problems for this competition: "(1) The construction of a voltmeter perfectly unaffected by changes of temperature or changes of the material entering in its construction; (2) if the solution of problem 1 be found impossible, the construction of a simple registering apparatus which can be added to a voltmeter in order to record the exact time during which the normal pressure has been exceeded." It is not stated whether foreign competitors are to be excluded; but as no mention is made of restricting this competition to Germans, it may be taken that electricians of any country may compete.

Liverpool Tramways.—There seems to be a good opening in Liverpool at the present for electrical tramways, and if our electrical engineers do not bungle, the latest and best method of street traction should be speedily adopted there. The Liverpool Tramways Company have made up their minds to get rid of horses and substitute mechanical traction of some kind, but of the kind the company do not yet seem to have determined—the company's report even mentioning engines worked by regulated explosives. Steam will not do because of the narrowness of the streets; compressed air and cables are too dear. Lord Bury has written to the papers with reference to this report, pointing out that electricity is now in a far better position than compressed air or cables, saying that after preliminary experiments they had laid down a temporary plant for purposes of demonstration on one of the branches of the North Metropolitan Tramway Company, where their exhibition carriage has been running with complete success for many months past. Now that this phase is over, the temporary plant has been removed, large and powerful stationary engines and dynamos are rapidly being erected on the spot where it stood, and five handsome cars, completed and wired for the reception of the electrical accumulators and motors, stand ready in the Leytonstone works of the North Metropolitan Company's car manufactory, waiting only till engines and boilers, which are on the spot at Barking, can be placed in position. A fortnight or three weeks will see the whole at work, and a complete service of electric cars will take the place of horses on the Barking section of the North Metropolitan Tramway Company. "The Electric Traction Company," continues Lord Bury in his letter to the *Daily News*, "and their electrical friends, the firm of Immisch and Co. (between whom and the Electric Traction Company a considerable solidarity of interests exists) have already at work, with good commercial results, pumping engines in mines where pumping was before expensive and unsatisfactory. They have electric launches running, and more in construction, and theirs is the only motor which has made telpherage a commercial success. In fact, in the wide field of electric traction they have acquired a position which permits me now to discard the reserve which during the experimental stage we were anxious to maintain. We hope that you and the directors of the Liverpool Tramways Company, and others who share with you the anxiety to see electric traction on a sound system, commercially profitable, will come and see our system at work on the North Metropolitan Company's line from Barking to Canning Town."

Light without Heat.—The recent researches of Hertz and Dr. Oliver Lodge into the possibility of production of light without heat may yet result in practical outcome in our own times. At least, there is already a claimant for the first honours in this department. Mr. A. B. Worth, of Greenport, Long Island, U.S., writing to the *Electrical World*, with reference to the subject of obtaining light without accompanying heat, says: "I am induced, as a matter of protection, to place before the public my own claims upon the subject. My work in this field was commenced in the latter part of 1884, and

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especially early in 1885, and has been continued, in one form or another, up to the present date. It is quite evident that when an electric current is passed through a filament a part of its energy appears in the form of useful light, and the remaining, and larger, part in the form of heat. But as light can exist and perform its various luminous, chemical, and electrical effects without the aid of heat, the latter, when emitted from the filament, is a total loss of electric energy. I have at present two or three methods, with their modifications in a more or less completed form, for overcoming this difficulty, and it is the expectation in the near future to produce a lamp the illuminating parts of which can be handled with impunity, while the same is giving forth a brilliant and soft light. Perfection will be reached when the filament will remain absolutely cold while under full action. A modified source of electricity is used in some cases with these lamps, as well as other sources of energy. The filaments are made in various shapes, some of them not at all resembling those we are accustomed to see, while in a few of the improved lamps none are used. The colour of the light emitted can be varied through the entire spectrum in certain forms of lamps. In his late address Prof. Brackett mentioned the idea of casting polarised rays of light upon the proper conductor, and causing an intermittency or alternation of an electric current. Now this is almost exactly the method shown by my drawings, and described in my papers of 1884 and 1885, except that the idea is there shown more developed. Some interesting facts in connection with this will be brought out sooner or later. A large quantity of accessory apparatus and different methods have been devised which necessarily cannot be mentioned here. Finally, I would like to put on record the fact that I have at least four distinct, and what it is thought to be practical, methods of generating electricity otherwise than by dynamos. The object of writing the above is as a means of protection, both from previous and future investigators. Progress has been greatly hindered from the beginning, and is at present, from the lack of funds necessary to perfect and introduce work of such new character and large dimensions, otherwise commercial results might possibly have been obtained about one year ago."

City Lighting.—The new Commission of Sewers was opened in state on Tuesday. Mr. George Manners was unanimously elected to the chair. The Streets Committee brought up a report on the subject of electric lighting, submitting draft conditions with a view to advertising for tenders. The report suggested that the main thoroughfares and public streets of the entire area of the City should be lighted by electricity, and, for convenience, divided into three districts, for all or any of which the contractors should be at liberty to tender. The first district comprises the area bounded on the north by the City boundary, on the east by Aldersgate-street, on the south by the Victoria-embankment, and on the west by the City boundary. The second is the central part of the City, and the third the eastern district. The contractors would be granted the exclusive right of supplying electricity for private purposes within their respective districts, but there were provisions regulating the amount to be charged to private consumers and for the division of profits by the reduction of charges after a dividend of 10 per cent. per annum was earned. The discussion of the report was adjourned. We believe we are correct when we state that the new Commission is animated with an active desire to deal with the matter at once, and that we may shortly look forward to a considerable "boom" in electric arc lighting in the City. In these desires the Commission have most people's hearty support. London is yet the most backward of all the capitals of Europe in its public lighting, but now we are going to stir, we trust the stir will be a satisfactory one in all respects. The area of the City which is to be lighted is as follows: District No. 1, West District, comprising the area bounded on the north by the City boundary, on the east by Aldersgate-street, St. Martin's-le-Grand, St. Paul's-churchyard (north side), Creed-lane, and St. Andrew's-hill, and thence along Queen Victoria-street to Blackfriars Bridge. On the south by the Victoria Embankment, and on the west by the City boundary. No. 2, Central District, and comprising the area bounded on the north by the City boundary, on the east by Finsbury-pavement, Moorgate-street, Princes-street, thence across Mansion House-street, along Walbrook and Dowgate-hill; on the south by the River Thames, and on the west by part of Upper Thames-street, St. Andrew's-hill, Creed-lane, St. Paul's-churchyard (north side), St. Martin's-le-Grand, and Aldersgate-street. No. 3, East District, comprising the area bounded on the north and east sides by the City boundary, on the south side by the River Thames, and on the west side by Dowgate-hill, Walbrook, Princes-street, Moorgate street, and Finsbury-pavement. The whole of the main thoroughfares in each district are to be lighted, and the following is a list of those thoroughfares: District No. 1 (west)—Holborn, Holborn-viaduct, Newgate-street, Charterhouse-street, King-street, Long-lane, Snow-hill, Chancery-lane, Fetter-lane, St. Andrew-street, Shoe-lane, St. Bride-street, Farringdon-street, New Bridge-street, Old Bailey, Fleet-street, Ludgate-hill, St. Paul's-churchyard (north side), District No. 2. (central)—Barbican, Beech-street, Fore-street, London-wall, part of (west of Moorgate-street), Gresham-street, Cheapside, Poultry, Watling-street, Cannon-street, part of (west of Dowgate-hill), Queen Victoria-street, Upper Thames-street (west of Dowgate-hill), Aldersgate-street, St. Martin's-le-Grand, St. Paul's-churchyard (south and east sides), Wood-street, King-street, Queen-street, Cripplegate-buildings, Milk-street, Aldermanbury, and Aldermanbury-postern, Coleman-street, Basinghall-street. District No. 3 (east)—Liverpool-street, Houndsditch, London-wall (east of Moorgate-street), Old and New Broad-streets, Bishopsgate-street Within and Without, Lothbury, Threadneedle-street, Cornhill, Leadenhall-street, Lombard-street, Fenchurch-street, Aldgate, Aldgate High-street, Gracechurch-street, Mansion House-street, King William-street, Cannon-street (part of, east of Dowgate-hill), Eastcheap, Great Tower-street, Upper Thames-street (east of Dowgate-hill), Lower Thames-street, Arthur-street East, Minories, Princes-street, Moorgate-street, Finsbury-pavement, Arthur-street West, St. Mary-axe. So far as the Commissioners are able to do so, they will grant to the contractor the exclusive right of supplying electricity for private purposes within the district during the term of the contract. The contractor will be required to supply electricity to any owner or occupier of any premises within a distance of 25 yards of mains, provided the owner or occupier enters into a fair agreement to defray or divide the cost of the service main, and to pay for the supply of the electricity. The contractor can charge the consumer for the amount of electricity supplied, either (1) by meter or (2) by agreement.

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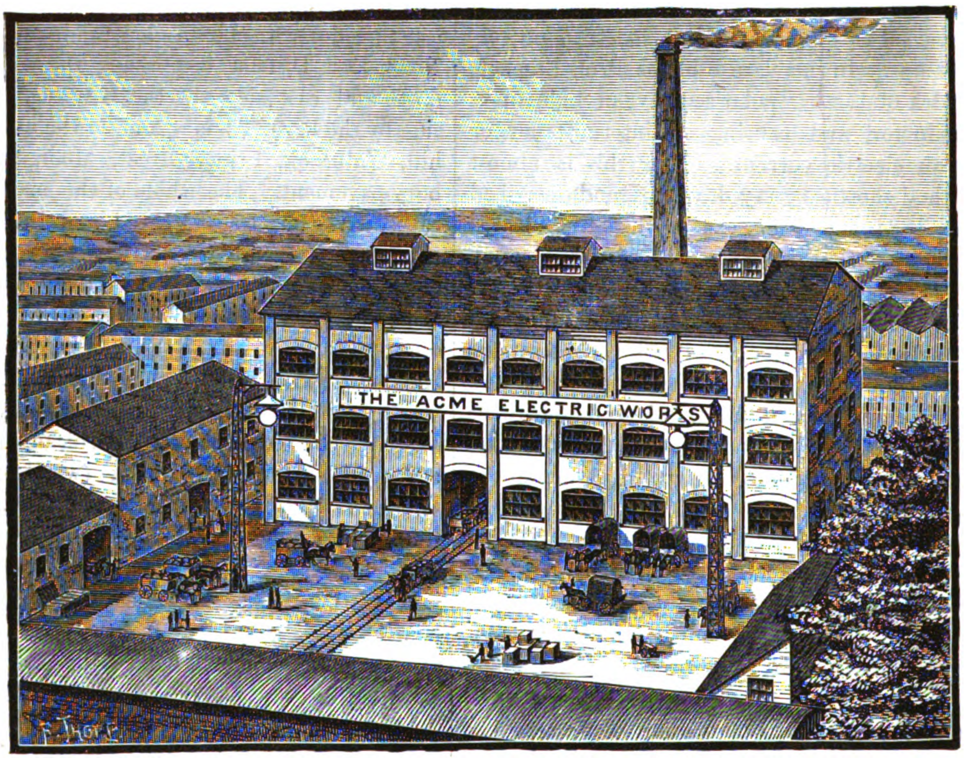
ELECTRICAL ENGINEERS.—V.

THE ACME ELECTRIC WORKS.

The firms of electrical engineers we have hitherto described have either been those formed at the beginning of the period of electric lighting activity, who have had laboriously to struggle through the days of depression and early experiment, or those who were already fully-formed companies who have taken up the more modern development of electrical engineering as a branch of their other electrical or engineering work. The Acme Electric Works, however, is an example of the sudden attainment of business success, due, at first, to the manufacture of a thoroughly good speciality, and carried forward by the constant and increasing demand for electrical apparatus and fittings on all sides consequent on the rebound of the electric lighting industry into good financial activity.

The Acme Electric Works are situated in Ferdinand-street, Kentish Town, near the works long occupied by Messrs. Immisch and Co., and are best reached by the North London Railway from Broad-street to Kentish Town station, which is within three minutes' of the works. Mr. Arthur C. Cockburn, A.I.E.E., who has the management of these works, was for some considerable time demonstrator to Prof. Ayrton, and afterwards to Prof. Sylvanus P. Thompson, at the Finsbury Technical College. It was here he made some accurate experiments on the fusing point of wires, specially with reference to the employment of electric cut-outs, the results of which he embodied in new forms of cut-out with loaded fusible wire, which he patented, and they were brought before the electrical world in the well-known paper before the Society of Telegraph Engineers. The success attained was immediate; large orders flowed in, and Mr. Cockburn relinquished his professional post to embark in the more lucrative business of manufacturing. A new form of quick-break switch was also devised by him in conjunction with Mr. Thomas, and arrangements were made by which these specialities should be manufactured, together with other electrical apparatus and instruments, at the Acme Electric Works, then situated in Tabernacle-street, Finsbury. The requirements of the business speedily became too great for these premises, and fine works were obtained at the present address, a view of which is given in our illustration. These works have been carefully laid out with special tools for manufacturing not only the switches and cut-outs, but all kinds of electrical accessories and instruments connected with electric lighting and engineering.

The works comprise some 12,000 square feet of floor space in three floors, with other premises for brassfounding, ironforging, battery making, carpentering, and lacquering behind the main building. The ground floor is occupied with the engine-room, lathes stores, and general offices. The machinery in use is mostly light lathes and drills, etc., and the power is obtained from one 4 and one 8 h.p. nominal Otto gas-engines, working to 24 h.p. One of these, it may be interesting to remark, was the gas engine originally put down at the Finsbury College. After his experience with steam-engines at other works, Mr. Cockburn elected for gas-engines in these, and is greatly pleased with the result, giving a strong testimonial to the Otto engines. Not only is there no worry in looking after the furnaces, but the actual cost of running, as shown in the monthly bills, is far less than with coal. The engines can be started at any moment, there is no banking up of fires, and the running of the engine requires no extra men. Extra power can also be thrown on at a moment's notice if required to test dynamos for customers. It is intended to shortly put down another gas-engine and a 500 light dynamo for completing the lighting of the works.



View of the Acme Electric Works, Kentish Town.

In the engine-room some large cone pulleys are being fitted up, so that dynamos can be tested at any desired speed. One of the features of these works, as will be seen further on, is that of electrical testing generally for clients; but besides this, it is intended that all dynamos and motors—whatever the make of machine—that are put in installations, as well as arc lamps, will be tested here before being sent away. A railway runs from back to front of the premises to facilitate loading and unloading from the waggons in the street.

STORES DEPARTMENT.

As the works are laying themselves out for supply of all kinds to the trade of electrical fittings, a considerable amount of space is taken up with stores in both raw and finished state. Casing of all kinds is stocked: wire and cable for installations; metal in plenty, rod, bar, and sheet—for screws, terminals, and parts of switches, etc., and steel and iron for magnets. In one large storeroom are large numbers of the various parts of switches and cut-outs, etc., stamped and partly finished, ready for making up in quantities. Battery pots and materials are stored in large numbers; bells and pushes, and Morse instruments, of which latter some dozens are in stock ready for dispatch.

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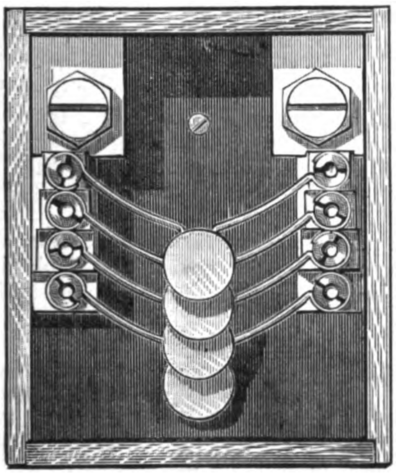
A very large quantity of glassware, shades, globes, etc., are stored for use in electric light installations. Ayrton and Perry ammeters and voltmeters are another speciality which this company have right to manufacture, and large numbers of the new spring instruments are kept in stock. Besides this, special stocks of Cock-

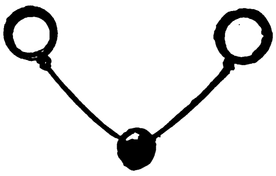


Step-by-Step Cut-Out.

burn's switches and Cockburn's cut-outs are kept: of the latter in all sizes, from ½ ampere to 200 ampere fuses, as many as 30,000 are kept in stock ready for immediate delivery.

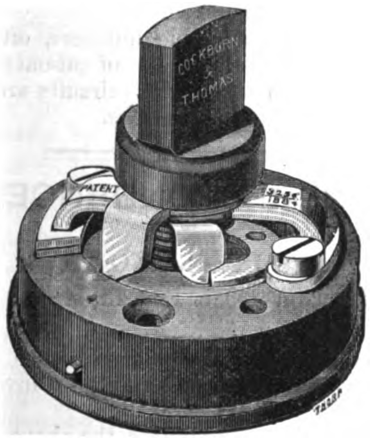
WORKS DEPARTMENT.

The works department is under the management of Mr. Sudworth, and is worked separately from that of the supply department, and a very complete system of ordering and checking out goods on order is adopted for quick delivery. The floors are arranged with long lines of light shafting, supplied by the Mechanical Appliances



Cockburn Fuse Wire.

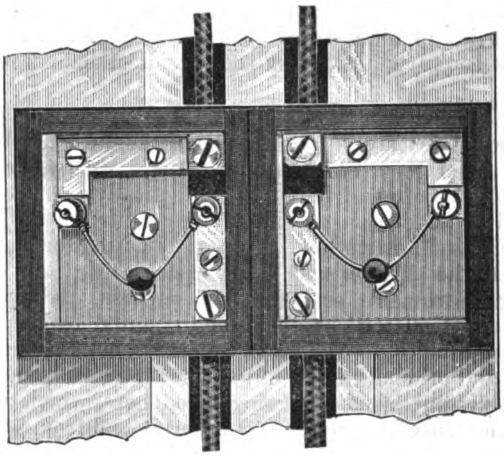
Co., Old-street, E.C., and a large number of light lathes and drills are fitted down the centre of each room, with vices and benches at the windows. The arrangement is very neat and convenient, with the newest and best type of tools for the purpose, carefully thought out and arranged by Mr. Cockburn, who seems to have quite a talent for mechanical organisation. The lathes and



Cockburn and Thomas Switch—Round Type.

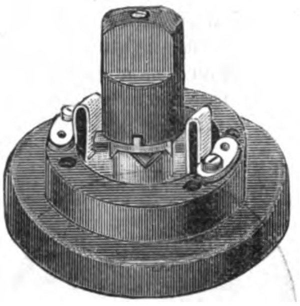
drills have all been specially designed and made for the requirements; the drills by Pfeil and Co., and the lathes by W. Cook, of Vauxhall-walk, all similar and interchangeable. A point worthy of note by users of shafting is the use of Bell's asbestoline, to which Mr. Cockburn gives high praise. Lubricators for the new lubricant were put in at the request of the Bell's Company, and have given most excellent results. The asbestoline is a kind of lard, very little is consumed, the shafting never runs hot, and no trouble at all is given, and no trace of oil, usually a great source of dirt and annoyance, is found from drippings on the flooring from the oilcups.

In this department we see cut-outs, switches, switch-



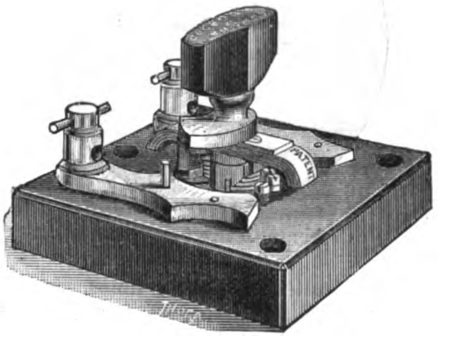
Double Pole Cut-Out.

boards in abundance in all stages of manufacture; wall-plugs in ebony and walnut; electric bells for the Admiralty; large numbers of telephones and telegraph apparatus. Here it may be mentioned that the Acme Works have a contract for making telephones and instruments for the New Telephone Company; as many as



Small Switch.

200 telephones a week have been supplied, and the company also make all their switchboards, and, in fact, most of their apparatus. Numbers of Ayrton and Perry instruments in various stages of completion occupy one section; they are the makers of the old form of these instruments, and also have the present exclusive right of manufacture of the new form of hot-wire instruments lately described by Profs. Ayrton and Perry. Terminals, caps, washers, screws, etc., are made in large quantities with special machinery, not only for use on the instruments made in the works, but also for the trade.



Cockburn and Thomas Switch—Square Type.

Behind the main building are two sets of outbuildings—one used as foundry and battery shop, and the other as carpenters' and lacquering departments. The foundry has lately been fitted up with smiths' fires and anvils, and with self-contained blast furnaces for brassfounding. The battery shed is used for making up Daniells and Leclanché cells. Ten carpenters are kept constantly at

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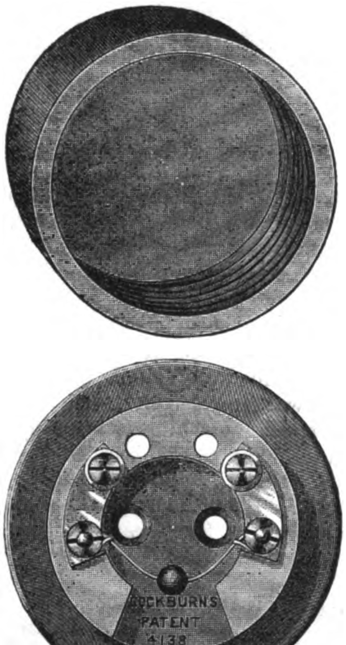
work in the carpenters' shop, principally making cases for instruments, and bases for switches and switchboards, etc. Coil winding for magnets and bells goes on here also, in which work girls are employed; as, also, in lacquering. One special department is arranged for the manufacture of the little "Cockburn fuses." A caretaker lives in the upper portion of these premises, and a staff of men is kept near at hand in case of sudden call for emergencies, or for installation work. A total of 130 men are now employed, including the outside staff.

Testing Department.

A special feature in these works in the future will be a testing laboratory, which is now being fitted up, designed by Profs. Ayrton and Perry, and practically carried out to their ideas under the superintendence of Mr. H. B. Bourne, of the Central Institution. This will be used for standardising all the Ayrton and Perry instruments, and recalibrating instruments sent for that purpose, and will also enable electrical tests of all kinds to be undertaken, under skilled assistance, for the trade, inventors, or experimenters. A new and original universal instrument—details of which are not yet published—is being fitted here, which will be able to measure from 0·1 to 600 amperes, and from 1 to 500 volts, in one instrument. Power will be arranged for tests of dynamos, etc., and a set of accumulators will supply current for testing small motors as well as lamps. Facilities for practically testing the fusing points of cut-outs of all types are also arranged.

Specialities.

The illustrations show the new form of the well-known Cockburn patent cut-out, mounted on china vase, with china cover. The little fuse of these cut-outs is shown separately, weighted with lead shot in the centre, to give a quick and clean break on slightest softening of the wire by excessive current. The fusing current in all cases is very very little over the maximum allowable current, and certainty of action is admirably secured.



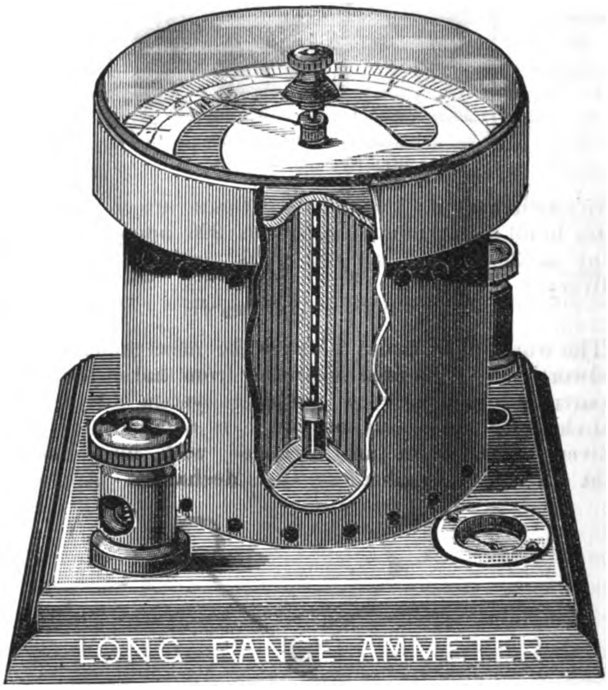
Cockburn Cut-Out on China.

The fuses are mounted on eyelet holes, easy to quickly fasten, and are put up in quantities for use in cardboard boxes, in sizes to go at from 1 to 200 amperes. The form used for double-pole cut-outs is also shown. Many thousands of these cut-outs are manufactured for use in installations all over the world. The General Post Office has some hundreds in use. The Royal Arsenal also has adopted them. The large size cut-outs for heavy currents are made as shown, with four successive steps of fuse wire, one behind the other, for ease of manipulation or of altering the safe carrying power.

Two forms of the Cockburn and Thomas quick-break switches are shown, which are made in very large quantities. These have already been described in the technical, and the action is well known. Suffice it to say that the connecting-piece is loose from the handle, which releases a spring, and breaks circuit very sharply and suddenly. They are made in slate, china, or serpentine, with either plain or ornamental covers, and are in great request for better class electric light installations. A newer type of small switch is also shown. In this the pull of the spring is downwards; the handle has a star-shaped projection fitting into the slot, and on turning the connection is quickly broken without possibility of the circuit being half on or off. It is a neat and simple little switch.

Instruments.

Electrical instruments of various kinds are made at these works—galvanometers, detectors, telegraph instruments, telephones, bells, etc. The principle speciality is of Ayrton



Ayrton and Perry Long Range Ammeter.

and Perry measuring instruments, of which the longe-range ammeter is one of the most in demand. New forms of these instruments are being perfected, and will shortly be brought on the market.

Double-pole Switches and Switchboards.

Switchboards and various arrangements of double-pole switches, with corresponding cut-outs arranged on the same base, are made in considerable numbers, often designed specially for installations; and sets of cut-outs, on slate or china bases, for distributing various circuits are also manufactured for use in large installations.

CORRESPONDENCE.

DOES INVENTING PAY?

To the Editor of the Electrical Engineer.

Sir,—There are few more fascinating occupations than inventing; and probably there is no branch of science or of engineering that is more prolific of inventions than electricity.

To electrical engineers, therefore, the above question will naturally present itself with greater interest than to almost any other body of men.

Everybody has heard of Graham Bell's lucky hit, of Mr. Swan's splendid *coup* on the advent of his lamp, and, more than all, of Edison's marvellous rise from a train boy to his present position. Tales, too, reach one's ears of this and that man who is drawing so many thousands per annum for some simple apparatus that we feel quite sure we could

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have invented very much better—if it had only occurred to us. It was just our luck that it did not occur to us.

Sad to relate, however, it must be confessed that, as a rule, inventing does not pay. It is very much like gold-digging. We hear of the fortunate ones who make a lucky find, but we hear nothing of the hundreds and thousands who find nothing, or worse than nothing, who lose health, fortune, and the chance of rising in an honourable, if plodding, humdrum employment. To understand the apparent paradox that fortunes are made by inventors, that still greater fortunes are made through invention, and that humanity at large has its path smoothed for it by invention, yet that inventing does not pay, it is necessary to go into the question of cause and effect. It is necessary to remember that, unfortunately, a man has but one head, one pair of eyes, one stomach; and that nature will only allow of that one set of apparatus working for a certain number of hours per day. Further, that to invent anything, however apparently simple, requires usually the expenditure of a very great deal of time, of money, and of thought. Also, that after the invention is, to all appearance, complete, the rough test of actual work has to be applied; and this test often discovers sources of failure the inventor never dreamt of. This little thing which worked so beautifully at home utterly refuses to do so in public. That part of the apparatus upon which so much time and labour had been expended, is found to have been designed upon principles and to conform to conditions that are the exceptions and not the rule in practical every-day life; and all this demands more time, more money, more thought, and, moreover, take years from the inventor's span.

And even when all these difficulties are surmounted; when the apparatus not only works in private, but in public, too; when the inventor's trembling hands have been rewarded at last by success in full view of those cold eyes that only want to see whether the thing works or not, and who only then give a qualified approval—"It works all right so far; will it stand such and such a test?"—who know nothing of the inventor or his struggles, and probably care nothing; to whom that which the inventor considers a grand triumph is only to them fairly good—what then?

Supposing all these dread ordeals to be safely passed. Are the inventor's troubles over? Not a bit of it. They have only just commenced. He is like the proverbial young bear. The troubles he has gone through are as nothing to those he has yet to face. "What," says some sanguine inventor, "do you mean to tell me that when I have made my apparatus work in public—mind, in public, sir—that my troubles are to come?" Assuredly, my dear sir; if not, you will be as lucky as the proverbial man who is better off than if he were born rich. Anyone can lead a horse to the water, but no one can make him drink. It is not anyone who can invent, and those who can sell their inventions are fewer still.

Remember, if your invention is to succeed, it must be able to advantageously displace apparatus that is now doing the work; and, further, it must so advantageously displace it that the buyer or user of the apparatus is a gainer pecuniarily by his purchase. You may prove, if you like, that your apparatus is a better one, that it does its work at a smaller cost; but will the user gain if it is out of order half the time?

Take the telephone, for instance, which is a remarkably favourable example of an invention. A merchant keeps so many boys to run between his two or more places of business, carrying messages, parcels, etc. He is approached on the subject of having telephonic communication between them. He likes the idea immensely. He will be able to *hear* if his employés are at work, etc., etc., and it will cost him less than the sum he now pays his boys—if all works well. Besides, he will not be everlastingly annoyed every time those urchins get playing marbles, etc.

But supposing that for one day in the week, at uncertain intervals, he cannot rely on his telephone, where is his gain? His business must go on; therefore his boys are kept, and the telephone becomes an expensive luxury, and Mr. A is apt to give his experience to his friends as he comes to and goes from business: "I like the thing immensely if it would only work. Do you know, I can tell which of my clerks is speaking to me—when it is in order; but it gets out of order so often I can't depend on it."

And so his friends conclude to wait. "A tried it, and had to give it up; always out of order, I shall wait; daresay the atmosphere has something to do with it; doosid clever thing, but too delicate for me," etc. And that, readers, is what rules the market value of an invention. Suppose someone calls on you to ask you to buy a new—anything. A chair, if you like. Haven't you a hundred reasons why your old one is good enough, though, perhaps, the minute before you were anathematising it?

And it is this long period of probation, the creation of a *clientèle*, which makes inventing so hard and unprofitable, unless it be the inventing of new pleasures. It is the finding a buyer for your invention. While you are going about to this and that possible purchaser, that stomach of yours, and, possibly, other stomachs depending on you, require to be fed three or four times daily. Your back, and theirs, require clothing. Other events demanding expenditure transpire, and so it may happen, and often does, that when at last success does come, if it does, all-round success, work in private, work in public, sale of invention, etc., the whole of the proceeds have been eaten up beforehand.

Therefore, for a new year's gift the writer would give *Punch's* warning. To those about to invent, don't. If an idea comes in your way that can be worked out at little cost, benefiting you in your knowledge of the science, follow it for that benefit, but don't expect further reward.—Yours, etc.,

SYDNEY F. WALKER.

CENTRAL STATIONS WORKED BY UNDERGROUND MAINS.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I read with much interest the letter from "Onlooker" in your last week's issue, but I regret that that gentleman has not carefully read the claim which is being put forward at the present moment by my company—which is that the station which the company has recently opened in Kensington is the first completed station in the metropolis designed for the accomplishment of electric lighting over a large area by means of underground mains.

At some future day this claim will only have a historical interest, but my directors would be sorry to put forward a claim which was incorrect, and in doing so they do not by any means ignore the work which is being done by the Kensington Court Electric Light Company; but from Mr. Erskine's recent letter in the *Times*, it is evident that the company do not claim to be working over an extended area.

It would be out of place to trespass upon your space by drawing attention to the various opinions which have been held from time to time as to the proper area for electric lighting, but it will be no doubt of interest to your readers to know that a high-tension system, such as that which has been installed by us in our Kensington station, is able to claim the power of coping with a large area, which a low-tension system, like that adopted by the Kensington Court Company, could not cope with.

Your correspondent's information in reference to the Zipernowski-Deri-Blathy system is most interesting; but as they have have not laid down a central station in the metropolis, the gentleman signing himself "Onlooker" must see that Signor Emilio Magatti's letter has no bearing whatever upon what he calls the repeated and positive assertions of the House-to-House Company that theirs is the first completed station in the metropolis for carrying out the work in the manner described.—Yours, etc.,

H. ST. JOHN WINKWORTH,
Secretary, House-to-House Electric Light Supply Company, Limited.

Bishopsgate-street, E.C., February 5.

Electric Organ.—An electric organ has been erected at Parkstone Church, near Bournemouth. The keys and pedals, which are at a considerable distance from the instrument, are controlled by electromagnets.

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

SUPPLY COMPANIES AND THE BOARD OF TRADE.

We know that according to Shakspere "Divinity doth hedge a King," while according to our own experience civilised humanity is hedged round by legislative restrictions innumerable, so that perforce he must walk along a very "strait" road. In fact, the acme of civilisation seems to be found in the shibboleth—restriction. From our earliest childhood to the last moment of life the one great text to be learnt seems to be "A man must not." The ending may be "marry his grandmother," or "take a walk along this road." The early commercial pioneers in any industry have a hard time in learning what they "must not" and what they "may do" without incurring legal disabilities of an awkward character. Nobody knows what he may do till he tries, and then the most innocent action may be met by restrictions in every direction, while other work of a more sweeping character goes scot free. When an attempt is made to introduce a new industry like the electric light industry, where conduits radiate from a centre to points of actual use in every direction, the difficulties of overcoming vested interests are enormous. Rights here and rights there have to be acknowledged and provided for, and this, in addition to the overcoming what may be termed the conservative inertia, which necessarily exists in all civilised communities, as well as direct and interested opposition.

The Board of Trade in its circular to the vestries has determined one point which electric supply companies must not do. According, as we read the circular, no supply company can by leave of the vestry take up the roads to lay mains. The company must, in the first place, obtain statutory powers, and—well, does it follow that, having the statutory powers, the company can proceed in opposition to the local authority, or must its consent also be obtained? This question is necessary, because statutory powers *may* in exceptional cases be granted, in spite of the opposition of the local authority. It may, therefore, happen that a supply company will occasionally find itself in the position most aptly described as being between the "devil and the deep sea." It may have statutory powers, but not the consent of the local authority, just as it may have the consent of the local authority without having statutory powers, although in the latter case there should be no difficulty—except increased cost—in complying with all the requirements.

It will be better to give the full text of Mr. Calcraft's circular, which reads as follows:

"Board of Trade (Railway Department),
"London, S.W., January 29, 1889.

"Sir,—I am desired by the Board of Trade to state, for the information of the Vestry, that their attention has been called to the fact that certain streets in the parish of . . . . have been, and are being, broken up with a view to the laying of mains

for the supply of electricity by persons having no statutory powers under the Electric Lighting Acts 1882 and 1888.

"The Board of Trade have been advised that no member of the public (and a company not possessing statutory powers would be in the position of a member of the public) can, either with or without the 'assent of the local authorities, interfere with public highways in such a way as to cause obstruction to the public, even though such obstruction were limited to the time during which they were executing their work.'

"It is, in the opinion of the Board of Trade, very undesirable that mains for the supply of electricity should be laid down in any street being a public highway by persons possessing no Parliamentary powers.

"The applications for statutory powers now before the Board of Trade show that there is considerable competition in the metropolis for the privilege of supplying electricity, and the difficulty of dealing with these applications in the general interest of the public will be materially increased if individuals or companies have laid mains without statutory powers, and, consequently, without the obligations which the Legislature has imposed for the protection of the interests of the public.

"It must also be remembered that the financial interests of electric undertakings which occupy streets with their mains, and supply electricity to the public, without statutory powers are by no means secured in the same way, and to the same extent, as if they possessed those powers; since, in the first place, their works run the risk of being stopped by the direction of a court of a law, at the instance either of some public authority, or of anyone who may at any time, now or hereafter, feel himself aggrieved; and since, in the next place, they do not possess the remedies for enforcing against their customers their charges, which the Legislature has given to those who obtain statutory powers.

"The status of applicants to the Board of Trade, and through them to Parliament, should be such as to ensure perfect equality to all, and there is danger that this might not be the case if any persons, either being or about to be applicants for statutory powers, were in the actual occupation of streets.

"It has become, therefore, necessary to consider the action which may have to be taken in view of the facts above referred to, and I am desired to request the early observations of the Vestry upon the points mentioned."

We have no doubt this circular has been drafted principally for the reason indicated in the fourth paragraph—the excessive competition in various parts of the metropolis—and to the efforts of some of the companies to follow Josh Billings' advice as given in the second line of the well-known distich:

"Happy the man whose cause is just,
Twice happy he who gets his blow in fust."

There has been a race to be in possession, evidently with the idea that possession is nine-tenths of the law, and there would be far less likelihood of getting the cold shoulder than by taking the chance of obtaining statutory powers among half-a-dozen strong competitors. We are not quite sure but that our sympathies are somewhat in the direction of the last line, and the company that has risked ten thousand pounds on laying mains will probably succeed in getting statutory powers for that particular district against those who promise to do the work. At any rate, there can hardly be two opinions as to what is past—whatever may be held as regards the future. There has been a race—let those who are in remain in, and those who are out seek new fields of operation.

With regard to the fifth paragraph of Mr. Calcraft's circular, depend upon it most of the directorates engaged in electric lighting operations in London at the present day are about as wideawake as you can make them. They will be able to take pretty good care of their own interests without any grandmotherly interference of the Board of Trade. As for the ability to buy and sell electric energy, and generally to get accounts in from their customers, that may be left to raise a smile upon the face of the unsophisticated aborigine—"Golly, massa, me hab light for noting." Worthy householders will think twice before they put any trust in circular phrases, and if they agree to buy so much electric energy will expect to pay for it—or take the consequences. As regards the penultimate paragraph, the position is described by reference once more to Josh Billings. The hurry of the man in possession has been taken with the one great object continually before him—to be in a position of inequality with his competitors. Whether his position is better or worse—*quien sabe?*

MOLECULAR PHYSICS AND THE NATURE OF ELECTRICITY.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I have before me a MS. paper, written a few years ago, on "Molecular Physics in High Vacuo," with a sequel essay on "The Mean Free Path of Atoms," in connection with the celebrated Crookes' experiments.

The subject is now renewed by an American electrician, Dr. P. H. Vander Weyde (*Electrical Engineer*, January 4th, 1889.)

His style of writing is by no means clear, and his statement of facts is very bald after a pretentious historical treatment of the subject. His version of the facts may be summarised thus:

(1) That dry air is a bad conductor of electricity, or what he calls a "good non-conductor." With ordinary power, it is an insulator; but with high power, a spark of 6in. may pass through it.

(2) That in proportion as air becomes attenuated, it becomes more and more conducting, up to the limit of ordinary air-pump capacity, when the aurora-like Geissler tubes are so familiar.

(3) That when the exhaustion exceeds one million-fold, air becomes a perfect non-conductor, evincing new properties, justifying Mr. Crookes' claim for a new fourth condition of matter, "as far removed from the gaseous state as gas differs from liquid."

What chiefly concerns me herein is the statement, which is the chief object of his paper, that Mr. Crookes has provided the true explanation of the new facts.

Of course, I object to his introductory estimate of both astronomy and chemistry, the former as dealing with the

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infinitely great, involving motions which are *indestructible*, "a perfect *perpetuum mobiles*." The latter with atoms immensely distant in proportion to their size, endowed with a miraculous "everlasting motion, as indestructible as is the motion of the planetary bodies."

We hold that both these assumptions are unwarrantable, if not wantonly absurd. I would rather moot that the facts or modern conceptions of astronomy, in harmony with all other facts, evince a wonderfully vast picture of life and death; that the intervals of planetary life may be vast in common with all the other features of a wonderful cosmos, but that these motions spring *from adequate causes*, and that all pass through the stages of infancy, maturity, and death.

As to the size of atoms or their distance apart, I have endeavoured to show that the whole thing is a mistake—that no experiment or calculation has ever been made for either, and the estimates, which are enormously discrepant, can only refer to the distance apart from centre to centre. When able men like Sir Wm. Thomson and others talk of the size of atoms or of their distance apart, they talk loosely or with inexactness.

I am tempted to quote the above paper at page 5. Mr. Fowler Preston says, according to the mathematical results obtained by Clerk Maxwell and others, "the molecules have a mean distance apart of $\frac{1}{7000000}$th of an inch, or ·000000143in.; Mr. Crookes estimates 21 millions to the inch; Clerk Maxwell, 50 millions; and Sir W. Thomson has hitherto estimated 500 millions to the inch, but now extends the range to 2,500 millions." From seven to 2,500 is a tolerably wide range, and if this is the kind of ground Mr. Vander Weyde likes to explore I envy not his taste. As to the mean free path of these atoms, extending from four millionths of an inch to 60 million miles, and their miraculous kinetic motions, I have said enough on these points, and pass them by here, except that the following is quite new to me: "The number of atoms in one cubic inch of the common air we breathe is represented by a series of more than 20 figures (rather vague!), and they are in constant continual motion to the number of 10 millions per second (yet more vague—what does he mean?); while the velocity is so great, that if moving in a straight line they would pass through a space of 11,000ft. per second."

Clerk Maxwell has shown that hydrogen must bombard its fellow atoms or the sides of a vessel with a mean velocity of 6,097ft. per second, "beyond our best artillery practice," in order to account for the observed pressure; as if that phenomenon were not simpler and better explained without a huge scaffolding of mathematical analysis based on a miracle of assumption.

The distinction between solids and liquids is curious: "When the amplitude (in solid bodies) becomes so great that the atoms turn over, and commence to rotate around their centres, the body reaches its melting point, and becomes a liquid. As the velocity of rotation becomes greater the liquid becomes hotter, until a new set of phenomena takes place. The atoms are projected into space, and in place of rotating they are propelled and repel one another, and as millions upon millions exist in the small space of one cubic inch collisions take place by billions, and we have the gaseous condition. If this be not wanton trifling, what is it?" How does he know that atoms vibrate so and so in solids; that in liquids this vibration is changed to rotation, while further heat changes this rotation back again to vibration on a larger scale, etc.? But perhaps the greatest absurdity of all is the new fourth condition, or "radiant matter."

Besides a full refutation of this in the paper referred to, I have since jotted down the following note: "A so-called radiator mill is shown, driven by the supposed mechanical stream of *radiant matter*. But the electromotor power from the induction coil is removed, and the platinum wire which had acted as the negative pole is now heated, and the dark heat *vibrations*, impinging on the vanes, set up the rotation precisely as before." Surely this tells very strongly against the "radiant matter" theory. Light, heat, and sound *vibrations* are dynamic affections, and either will set a mill rotating. The vanes of a windmill radiate, but we don't call such mill a radiator. Mr. Crookes tells us what are the distinguishing properties of "radiant matter."

(1) "Radiant matter, when interrupted by solid matter, casts a shadow." This is precisely what takes place with the radiant forces of light, heat, and sound.

(2) "It exerts mechanical action where it strikes." This is precisely what radiant force does in the window-breaking intensity of loud concussions.

(3) "It is deflected by a magnet." This is precisely what takes place with the radiant or linear lines of polar force.

(4) "It produces heat when its motion is arrested." This is precisely what takes place when the radiant affections of light and heat are arrested.

Mr. Vander Weyde says: "Heat and light will both pass through a vacuum perfect enough to obstruct absolutely the passage of electricity." But here, again, and throughout what follows, we have the interminable confusion subsisting between matter and force, and all depends upon the meaning he attaches to the vague term "electricity." It is commonly held that electricity is convertible into heat and light! But that is only true of the dynamic *force* of electricity, and in principle it is equally true of the hydraulic *force* of water, but we do not say that water is so convertible, and we know that the ions of electrolysis are material and inconvertible, and also that the electric current is absolutely inconvertible, seeing that the quantity of electricity going into a lamp is the exact measure of the current passing out.

There is no more consumption or conversion of this electricity in electric lighting than there is water consumed or converted in the production of hydraulic effects of any character or magnitude whatever. Anyone wishing to further entertain this subject may peruse the above paper on application to—Yours, etc.,

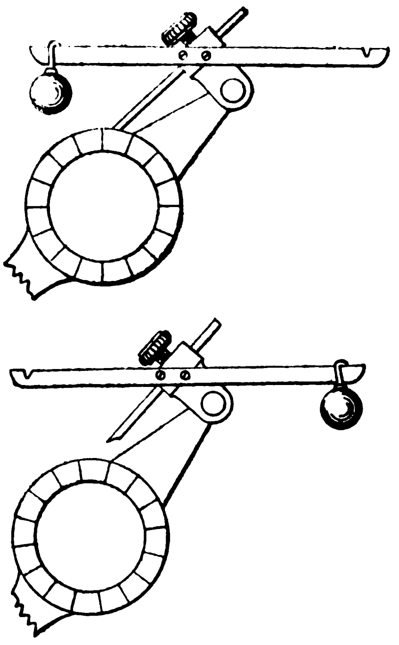
SAM. E. PHILLIPS, F.C.S.

Wokingham-road, Reading, Berks.

BRUSH-HOLDER.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I enclose a sketch of a new form of brush-holder which ought to be used on every dynamo intended for



practical use. I have found from experience that no form of holder in which a spring is used is satisfactory for two reasons—firstly, because the spring is sure to become soft and useless through the heat to which it is raised; and secondly, because it is generally next to impossible to get the man in charge of the machine to keep the right amount of tension on the spring. If the machine sparks, he will, in nine cases out of ten, increase the tension, with the result that the commutator will be worn out in a few months. I have known this happen in a great number of cases, and have often seen the brush-holders (even in machines by the best makers) tied over with string to increase the pressure of the brushes on the commutator.

In the case of the brush-holder shown in the sketch the

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balls can be easily adjusted to give the exact amount of pressure required to give a good contact with the least possible wear and tear, and after leaving the factory there is no chance of damaging the machine by increasing the pressure. This may seem a small point, but it is just the neglect of these small practical details in the construction of electrical apparatus which so hinders the progress of electric lighting, especially in the case of isolated plants, where a collection of spare parts cannot be always kept on hand.

I do not know of a dynamo in the market (with the exception of one of Parson's high-speed machines) which is fitted with any form of gravity brush-holder. In every case some more or less complicated piece of apparatus is used, controlled by one or more springs, which costs considerably more to make, is not in any way more efficient, and is constantly getting out of order.—Yours, etc.,

Duart House, Lee, Feb. 5. W. M. HITCHCOCK.

INFORMATION WANTED.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—In your issue of Jan. 4th, this year, in reviewing the different firms, you stated that Messrs. Immisch and Co. had made for the Wharncliffe Silkstone Colliery a self-contained locomotive (which I presume is worked by secondary batteries). Could you kindly give me a few more particulars? I should like to know how much the engine weighs, and how much it can draw; whether the wheels are single or coupled, and what size, and what kind of gearing is used. If you think of publishing a sketch, would you kindly let me know? I am afraid that I have asked more questions than you like to answer, and would take up too much space. Any information will be thankfully received. Yours, etc., A. M. BUSHELL.

36, Queen's-road, Bayswater.

EXTRAORDINARY PHENOMENON OF LIGHTNING.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—This (Saturday) evening, February 2, at 7.35 p.m., wind N.W., sky cloudy, thermometer 38deg. F., a tremendous fireball, about two metres in diameter, accompanied by a fearful explosion of only two seconds' duration, descended from the sky, which seemed to split into four quarters upwards, showing a *bluish* fiery light. The explosion was unlike thunder, and more like a fearful detonation of explosives, which was followed by a snowfall of only two minutes' duration, leaving 1½in. of snow on the ground, the atmosphere being after splendidly pure. It would be interesting to know if this phenomenon has been observed in this and other quarters, and under what condition.—Yours, etc., ERNST FAHRIG.

Stamford Hill, London, N., Feb. 2, 1889.

ON THE RELATIVE PROPORTIONS OF RING ARMATURES.

BY R. S. DOBBIE.

Being a great admirer of the ring armature, the value of which the French Senate and Chamber worthily acknowledged by awarding the Volta prize to M. Gramme, I think that a few remarks on the proportion of the radial depth to the axial length would be interesting to many readers of this journal. In the design of a dynamo the mass of the armature is the first thing to be taken into consideration. A given weight of iron can be arranged in many ways, each of which under similar conditions of peripheral speed can give equally good results. For instance, the performance of an armature in which the radial depth of core is half the radius, and placed in a system of magnets adapted for it, can be equalled by an armature in which the radial depth is, say one-tenth the radius of ring, the fields in this case also being adapted to it, and the conditions of speed, mass, and total strength of magnets being the same in both. And not only does this hold good here, but also with the drum armature, which I look upon more as a modified Gramme ring, in which the radial depth of core nearly equals the radius of the armature, than a modified Siemens shuttle armature. A drum armature with equal speed and field can be strictly compared with one of the ring type of equal mass.

The core of any armature has three important functions to perform. First, to use a conventional term, it acts as a path for the lines of force from the field-magnet; second, it has magnetic lines of force induced in it by the action of its own coils; and third, it acts as a support to these coils. Each of these functions involves the following conditions respectively: First, the path for the inducing magnetism from the fields, and hence the surface presented to the pole pieces *must be large*; second, the lines of force generated in the armature *must be few*; and third, the shape or proportion of the ring influences the *length of a convolution* compared to its mass. Since the circle is the shortest line which can enclose a given area, theoretically considered the circle should be the section of a Gramme ring; but the difficulty of constructing this shape has led to the almost universal employment of rectangular sections, with the corners rounded for convenience of insulation and winding. Let us now consider the effect of lengthening the rect angular section in proportion to the radial depth of the ring. We have here six rings, Figs. 1 to 6, in which the sectional area, a (= 16 square inches), and the mean radius, $m\,d$ (= 12in.), are equal in all the rings. It will be seen that the length of one convolution, l, creeps up in a startling manner, and it is obvious that if this were the only consideration, the square section (barring the circle as impractical) should be selected.

But there are other points before us, such as the clearance between the core and the pole-pieces, which I will call the inductive space, and which must be small in a radial direction and large in area. For the sake of illustration and comparison, we will suppose that 50 per cent. of the angular breadth of the ring is covered respectively by pole-pieces, first on the outside surface only, as usually practised, which area is designated by p_1 in the tables accompanying the figures; second, by pole-pieces on the outside and the two sides, as in Mordey's dynamo, and designated by p_3; and third, by pole-pieces on the outside and inside, as in the Fein and Sperry dynamo, and designated by p_2. It will be noticed that at the stage of elongation shown in Fig. 4, the value of p_3 ceases to be larger than p_2. It will thus be seen that the longer we make the ring the greater is the surface presented, but so also is the length of one convolution, l.

As the ring, as just stated, serves as a path for the magnetic lines of force, it is evident that the area of the field should be in proportion to the area of the armature, and the area of the pole-pieces should also be proportional to a given area of field-magnet. This latter point is one that I have never yet seen any hard and fast rules laid down for. Now, theoretically, it is evident that the sectional area of a field-magnet should be equal to twice the area of the ring (remembering that in every ring the lines of force from the field-magnets have two available paths). For example, those shown in the figures being 16 square inches, the field-magnet should be 32 square inches; that is, supposing that things could be so arranged that all the lines of force from the field-magnets could be utilised in the armature, and, of course, assuming that the saturation was the same in both. In practice, the magnets are generally made of metal inferior to that of the armature; but as the latter contains quite a percentage of inert matter in order to carry out the necessary lamination, and as constructors are more and more awakening to the fact that wrought-iron magnets are cheapest in the end, the balance becomes more equal; so that in the end we can, in practice, allow only for a waste of lines of force, and if, indeed, it is worth while, a little difference in favour of the superior metal that armatures are usually made of.

From my own observation I have found that the area of the armature, multiplied by two, is ample, if the field-magnets are of wrought iron, and the length of the inductive space is small (not exceeding ⅜in. in the above example). The fields should be nearly, if not quite, saturated in order to ensure steadiness; but the magnetism induced in the armature should be considerably short of

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saturation, as an armature will heat even if laminated, should it be magnetised to saturation, thus still further reducing the necessity of difference between the respective areas. And here let me make a note about lamination. It is often found that constructors use extremely thin sheets separated by the very thinnest paper, which by no means *thoroughly insulates* one plate from its neighbours. I believe that it is a useless refinement to have the disc forming the armature thinner than one-sixteenth of an inch. If these are really substantially insulated, so that after being turned true the plates have a resistance of over 10,000 ohms between each other, or, more practically speaking, will not allow an ordinary magneto bell to ring through, it can be relied upon that *insulated lamination* has been properly carried out.

Taking, therefore, for the sake of argument, the ground that the area of a field-magnet is twice that of the ring, let us return to the question, How large should the surface of the pole-pieces be? Referring to the figures, and assuming that 50 per cent. of the angular breadth is enclosed by pole-pieces, we then have for the different shapes, ignoring the circle as impractical, the values shown in the tables accompanying each diagram.

as the many examples we can all call to mind show that after a certain limit is reached it is useless, and even detrimental, to go beyond; but the angular breadth can be reduced with advantage, and *more poles may thus be presented to the ring.*

One more point is brought out by comparing the figures. The difference between the internal and external diameter of the square-section ring, Fig. 2, is far greater than in Fig. 5, and if both were wound with, say, one layer of wire, inside and out, with no overlapping, the difference in number of turns would be *20 per cent. in favour of the long ring* (Fig. 5). It will thus be seen that while the length of a coil becomes greater as the ring increases in length, so does the internal diameter of the ring, thus allowing a greater number of turns, or a thicker wire, to be used.

Referring again to Fig. 2 and Fig. 5, we have 16in. and 20in., respectively, as the length of one turn—that is, a difference of 20 per cent. in favour of the square section, Fig. 2; and as the E.M.F. is proportional to the number of coils, and the current is proportional to the resistance, we have things balanced, and only have to choose between the difference of constructional advantages in them.

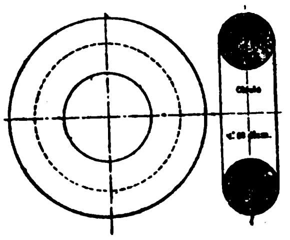

Fig. 1.

D=16·53 in. l=14 in.
d= 7·44 „ a=16 sq. in.
md=20·0 „

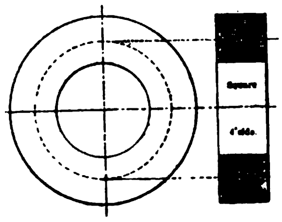

Fig. 2.

D=16 in. a= 16 sq. in.
d= 8 „ p_1=100 „
md=12 „ p_2=150 „
l=16 „ p_3=250 „

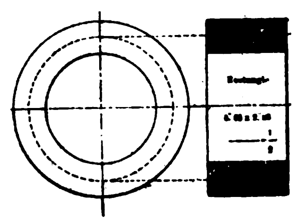

Fig. 3.

D=14·83 in. a= 16 sq. in.
d= 9·17 „ p_1=131 „
md=12·0 „ p_2=212 „
l=17·0 „ p_3=238 „

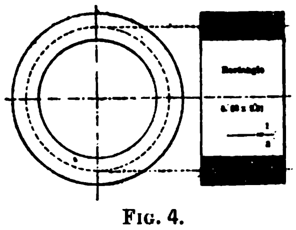

Fig. 4.

D=14·31 in. a= 16 sq. in.
d= 9·69 „ p_1=155 „
md=12·0 „ p_2=260 „
l=18·5 „ p_3=243 „

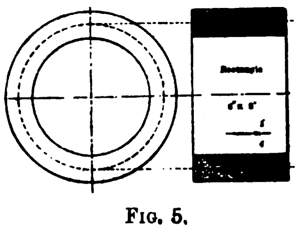

Fig. 5.

D=14 in. a= 16 sq. in.
d=10 „ p_1=162 „
md=12 „ p_2=287 „
l=20 „

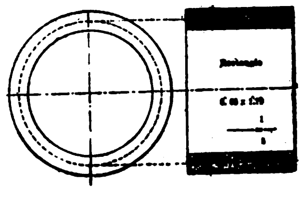

Fig. 6.

D=13·79 in. a= 16 sq. in.
d=10·21 „ p_1=191 „
md=12·0 „ p_2=333 „
l=21·4 „

D, External Diameter of Ring; d, Internal Diameter of Ring; $m\,d$, Mean Diameter of Ring (equal in all the figures); a, Area of Cross-section (equal in all the figures); l, Length of One Turn of Wire; p_1, Total Area of Pole Pieces, embracing 50 per cent. of outer periphery only; p_2, Total Area of Pole Pieces, embracing 50 per cent of outer and inner periphery; p_3, Total Area of Pole Pieces, embracing 50 per cent. of outer periphery and the two sides.

So many machines have the surface and also angular breadth of the pole-pieces so enormous, compared with the section of the field-magnets, as to be simply ridiculous. On such machines I need hardly add that the "beautiful spark playing around the brushes" that is so much admired by country cousins is ever present. There is no doubt that the present tendency is in the direction of narrower pole-pieces. I do not remember seeing a continuous current machine in which the area of pole-pieces was less than 1·5 that of the field-magnets, and I have yet to hear of any machine being condemned on account of having the area of the pole-pieces too small. I know from practical experience that about 60 square inches of pole-piece is ample for a magnet about 6in. in diameter—*i.e.*, 28·2 square inches—and four such magnets and pole-pieces could be presented to the square section ring, the pole-pieces embracing the outer periphery and the two sides (p_3).

I think that modern practice in alternating current dynamos where the area of the pole-piece frequently equals the area of the field-magnet, might be at least considered in the construction of continuous current machines, as both are fundamentally the same in principle. The resistance of the inductive or air space is overrated by constructors,

In conclusion, it will be seen that the various forms have their own peculiar advantages. The square section has the advantage that the length of one turn is a minimum for the area of the mass enclosed. If the pole-piece embraces the outer periphery and the two sides with 50 per cent. angular breadth, the area offered is ample. In rectangular sections the area of pole-pieces increases faster than the length of one turn. The winding is more symmetrical and lamination is more easily carried out; but if the length is increased beyond a certain limit the length of a turn becomes objectionable.

These questions will afford ample exercise for those inclined to grapple with them. So many minutiæ are involved, that a careful consideration of the conditions to be fulfilled is very necessary to success, and opinions as to the advantages of the various forms can by no means be given off-hand.

The subjects touched upon in this paper suggest many others, such as the number of poles, length of inductive space, and its relation to area of pole-piece and area of field-magnet, together with the ratio of radial depth of core to the mean radius of ring. These are subjects that give abundant material for further study.—*The Electrical World* (New York).

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ELECTRIC METERS FOR CENTRAL STATIONS.

The following discussion took place upon the reading of Prof. Forbes' paper on the above subject (given in full in our last and previous issues) at the Society of Arts:

Mr. R. E. Crompton said he had had some practical experience with the Aron meter, but it had been principally through a third party—Mr. Miller, who could have spoken with much more authority as to its performance. They had at first enormous trouble with it, but were eventually successful, and it was through Mr. Miller that many of the improvements had been made. They commenced with another form of meter, which was not satisfactory, and which was now superseded by the Aron meter. In its original form the clock was started by a detent when the current was turned on, but that gave endless trouble, as the clock did not always start, and consequently they lost, not only a record of the rate between the visits of the attendant, but actually lost all record, as the meter registered back, which was a very serious affair. Mr. Miller made some suggestions which resulted in the simple clock which was now employed, and ran for 30 days, and since then many of the difficulties had been removed. He had recently spent some time in Berlin, and found that they were thoroughly satisfied with that meter, but he should say that it only registered the current supplied to incandescent lamps, whereas the success of the Berlin station depended on arc lamps, which formed about three-fifths of the whole, and they were charged mostly by contract. At Kensington they had never sold current otherwise than by meter, in which he believed they stood alone. At Liverpool, however, there was a central station which worked largely by meter, and by one which had not been mentioned—viz., the Chamberlain and Hookham, which, he was told, had been working there for some weeks, and proved as accurate as the Aron, and was in some points superior, though he did not know the particulars. He could endorse what had been said about the use of the Edison meter in America. He believed no meter had been more aspersed, but at the same time it had done infinitely more real work than any other, and it had been very unwisely neglected in this country. At the time Mr. Ferranti was bringing out his meter, Mr. Kapp and himself were experimenting on exactly similar lines, but Mr. Ferranti was a few days earlier in applying for his patent. With regard to lamps, if Prof. Forbes had had practical experience in lighting private houses, he thought he would advocate 8 c.p. lamps, because we had to compete with gas and keep down the annual bill. The greater part of the expense of lighting was incurred for passages, staircases, and so on, and for this purpose a unit a little over eight candles answered extremely well. Everyone who saw the so-called 16 candle lamps worked at the volts at which they were sent out by the Edison-Swan Company, admitted there was a great waste of light when used in such situations. These lamps originally yielded 18 candles, or more, but since the improvement in the manufacture of the lamps, they had been able to work them slightly in excess of what they were marked. Those marked eight candles and 97 volts could be worked at 102, and yielded about 11 candles when new, and when quite old the original eight. Customers who could buy the larger lamps if they liked preferred the smaller ones, and more than three-fourths of those in use were the smaller unit. This was not so in shops, clubs, or hotels, where larger lamps were more satisfactory; but to make the electric light spread rapidly, and not frighten the people by the cost, the smaller lamps should be encouraged. He greatly admired the magnificence of the Berlin central station, but it was very costly, and he thought the same result could be obtained in England for very much less money.

Prof. Ayrton, F.R.S., after paying a tribute to the modesty displayed in the paper, which he would endeavour to emulate, said he should like to break a lance with Prof. Forbes on the old dispute as to whether electricity should be charged by quantity or by energy. It seemed to him that people were somewhat influenced by the meters they had to supply, and naturally liked people to pay for a thing the meter would measure rather than that the meter should measure the thing they ought to pay for. No doubt, if it were possible to maintain a constant potential difference between the supply mains, the total quantity supplied in a given time was all that need be considered, but this constant difference of potential was not maintained. Prof. Forbes admitted there was a 2½ per cent. variation; but that amount of variation in the volts meant a very great difference in the amount of light, which was really what the customer thought about. He did not care about volts, watts, or anything else; he bought light, and wanted a meter to measure what he was paying for. A variation of 2½ per cent. in volts—and it was more in practice—meant a considerable drop in the light, which was about proportional to the cube of the volts, minus a constant, as shown by the experiments made by Prof. Perry and himself on several types of incandescent lamps some years ago. The other day he was in St. James's Hall, during an afternoon performance, when the light went down so much that the gas had to be turned on full. Supposing you were paying by current, you would pay not much less than if the right voltage were maintained between the terminals, and if a few more lamps were turned on the total current would be the same, but the light obtained would be nothing near the same, so that during that half-hour the customer would be paying the full gas bill, and the full electric light bill as well. In fact, so far from employing a meter which took no notice of any variation in the volts, as was advocated by Prof. Forbes, he was not sure but that the meter ought to take into account some higher power than the first of the volts, so that it would measure, perhaps, the integral of the product of the current into the square of the volts, seeing that the light fell so rapidly with the fall in the volts; but whether this was done or not, they certainly ought not, he thought, to be satisfied to neglect variations of even the first power of the volts on the indications of the meter. There was one point about the simplicity of testing which Prof. Forbes had not referred to, which existed in retarded clock meters, but in no others. During the time you were not using the electricity you could check the accuracy of such a meter, because the clock, which was simply retarded when the current was supplied, was not retarded at all when there was no current passing, and you could therefore compare the going of the meter during the day with any respectable watch, and with which it ought to keep time. No one of the other meters could be tested in that way. A way Prof. Perry and himself suggested some years ago of getting over the possibility of cheating in an ergmeter for measuring the product of the current into the volts, had a pendulum wound with wire, the wire round the pendulum being a shunt to the main circuit. By putting a magnet near the clock the consumer might prevent it being retarded so much, but it was proposed to occasionally reverse the current in the whole system, which could easily be arranged, and the result would be that anyone who tried to cheat by the use of a magnet would be as likely to increase his bill as to lower it. He agreed in the objection which had been raised to contacts in meters, but there was one meter, patented some years ago by his colleague and himself, which was not open to the same objection, though it had two contacts. It was a motor, the field-magnets of which were wound with thick wire, and there was a continuous circuit through them—no make or break at all. The rotating armature was wound with very fine wire of high resistance, and there were two brushes to lead the shunt current through the armature, and any changes in the resistance of the contact of these brushes made very little difference in the total resistance of the shunt circuit. There were no brushes in the direct circuit, and any slight amount of dirt which in time accumulated under the brushes in the shunt circuit introduced very little error. He ought to mention in passing that the ergmeter had no defect, in that it measured what the customer ought to pay for. If the supplier could keep a constant difference of potential between the terminals, then the ergmeter became a coulomb meter, but if the supply were variable the ergmeter checked the supplier if he did what he ought not to. He thought Prof. Forbes must be in error in speaking of fluid friction being proportional to the square of the velocity; with small velocities the retardation was not proportional to the square but to the first power of the velocity; with a velocity, such as existed in the beautiful instruments on the table, the vanes were not moving much faster than the needle in a ballistic galvanometer, and the damping correction of that instrument was, as was well known, on the principle that the retardation did not vary with the square of the velocity. Indeed, their own motor ergmeter, in which fluid friction was used, and which was patented in 1882, was based on the principle that the friction was proportional to the first power of the velocity. There they wanted to measure the time integral of the product of the current passing through the field-magnet, and the current passing through the armature, which integral was directly proportional to the energy. The force-causing motion was proportional to the product of the two currents, and if it were assumed that for slow velocities fluid friction was proportional to the velocity, the distance travelled through by the armature would be proportional to the watt seconds, or, in other words, to the total energy supplied. If the retardation were proportional to the square of the velocity, the meter would not have worked satisfactorily. While on the subject of fluid friction, he would allude to one defect with all these motor meters which had prevented them improving and introducing their own motor ergmeter. You wanted simpler fluid friction, not solid friction. You must not have the friction of mechanism, and therefore it was necessary to reduce the dials and recording mechanism to such very minute dimensions, and to make them so delicate, that great difficulty was introduced. That was the great difficulty with the Ferranti meter; if he had no recording mechanism his meter would have been perfect; but the friction introduced by the dial mechanism was a great difficulty, and he understood that though Mr. Ferranti had many thousand lamps at work where the current was measured by these meters, he was not yet satisfied with them, and was sending to America for machinery to make more delicate dial mechanism. The retarded clockmeter had no such defect, as the mechanism was not driven by the current. In one sense it was a defect to have to introduce another motive power, but by so doing you got over the difficulty he had mentioned. The friction of the mechanism introduced no more inaccuracy than was to be found in a good chronometer. With a motor meter it was absolutely necessary to reduce the dial mechanism to the smallest possible dimensions. His colleague and himself owed a debt of gratitude to Dr. Aron for the way in which he had carried out the principle they had put forward, and, as his agent had wisely commercially acknowledged their claims to priority, there was perfect accord. He was a little surprised to hear of the success of the Lowrie-Hall meter, which was based on the assumption that the alternate current, when passing through a voltameter or an electrolytic cell, produced no decomposition; but this had been found from the experiments made by his students, an extremely difficult condition to arrive at. It meant that if you sent an alternate current through a voltameter no gas would be produced, but, in fact, you could easily get a considerable amount produced, and you could get copper deposited with a current making many thousand alternations per minute. He was much surprised, and at the same time much pleased, to hear that this difficulty had been successfully surmounted. At the end of the paper Prof. Forbes had briefly described a meter which gave its indications by means of the evaporation of alcohol. A meter on the same principle was made at the beginning of last year by Mrs. Ayrton, mainly by her own experiments at home, though tests upon it had been subsequently made by her at the Central Institution. In that case, water was evaporated by the passage of the current; the water fell through a tube, and, according to her design, worked a recording mechanism, and was finally carried back to the reservoir to be re-evaporated. He had nothing to do with the invention himself,

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and had, in fact, rather discouraged it, in consequence of the difficulties of such an investigation. He, therefore, now penitently desired to place her meter on record.

Messrs. Shoolbred, Smartt, and **H. Swan** also joined in the discussion.

Prof. Forbes, in reply, said he was very sorry Mr. Miller had not been present to give his practical experience, but he understood that at Berlin the single clock-meter was found more successful of the two types of Aron meter, and he was surprised to hear Mr. Crompton intimate that was not so at Kensington.* He was very sorry there had been any meter which had been successfully employed in central stations which he had not described. He was aware that Messrs. Chamberlain and Hookham had devised one, but did not know it had been in practical work, and he should make it a point to learn more about it. Since Prof. Ayrton had expressed a desire to break a lance with him on certain points, he should be quite willing to discuss the point in a few sentences. Prof. Ayrton tried to reduce his proposition to an absurdity; and he would endeavour to do the same with what Prof. Ayrton had said. It was intimated that those who made meters did not make them to satisfy the wants of the customer, but tried to make the wants of the customer meet the performance of the meter. The customer wanted to measure the quantity of light, which was proportional to the cube of the volts, and there was no doubt about it, according to Prof. Ayrton, the erg was the proper thing to measure, since this is what his meter measures—whilst he (Prof. Forbes) said the coulomb was the thing to measure—the total quantity of current passing through. He said no. When the lamps were burning down very low it was a great shame the customer should be charged almost as much as when they were burning brightly. Now, supposing he were supplied by meter and charged by ergs by the volts multiplied by amperes. Those who supplied the current would want to send a greater pressure through the lamps than the customer wanted, and so break them down, and the customer then would not only be injured by having his lamp destroyed, but insulted by being asked to pay more in his meter account for this. He thanked Prof. Ayrton for his information about another inventor who had been working on the same line as himself; a great many had tried evaporation, but he had not seen one which made the results proportional to the current going through the meter. With regard to the cost of meters he had very little information. In America the idea was that they ought to cost about £1 to manufacture, and sell at about double that price, but he did not think they would come down to that in this country. They would probably sell for from £4 or £5 up to £18 to £20.

The **Chairman**, in proposing a vote of thanks to Prof. Forbes, said it was quite true that he felt it extremely depressing to walk through the dull and dismal streets of London after coming from New York, which was brilliantly lighted by electricity; but on hearing such papers as this, he felt that there was a possibility of that depression being removed. He himself lived in an atmosphere of electricity, his own house being lit by it, and whenever he went to see his friends he could only pity them for living under the depressing influence of gas; and he hoped the day was not far distant when others would be as comfortable as himself. He believed we were on the eve of a boom in electricity. Only yesterday the Commissioners of Sewers of the City of London decided on issuing a specification and inviting tenders for lighting the City, and it was to be hoped that, before the end of the year, Fleet-street, Ludgate-hill, and Cheapside would even surpass the famous Unter den Linden. With regard to 16-c.p. or 8-c.p. lamps, he agreed with Mr. Crompton that when Prof. Forbes had had more practical experience of the fitting up of private houses, he would come to the same conclusion as Mr. Crompton and others, that the proper candle-power to use in houses was 8 or 10. In a large hall it would be absurd to use such lamps, but there really ought to be a new system introduced, as Mr. Shoolbred had said, of speaking of lamps not by candle-power, but of so many watts. The standard lamp in his practice was one of 50 watts. If people in the colonies or abroad sent home indents for an electric installation for so many thousand lamps no one would know what they wanted; but if they sent for so many lamps of so many watts they would know exactly what to send, the proper dynamo to give the current, and the batteries required to maintain it. Throughout the Post Office they commenced with 16 candle lamps, but found that 10 candle gave all the light required. The real question was not so much the power of the lamp as the proper distribution of the light. When you had decided on the amount of light required to read or write, or to do any particular work, it was easy to calculate whether the lamp should consume 30, 50, or 100 watts, because that simply depended on the position in which it was placed.

The vote of thanks was carried unanimously, and the meeting was adjourned.

Mr. J. W. Swan writes to the *Society of Arts Journal* as follows:

"Prof. Forbes has given us an admirable *résumé* of the present state of electric current meters, or at least such of them as have come into practical use. If he had extended his view so far as to embrace experimental meters, it would have been necessary for him to have given—not a lecture, but a course of lectures. The number of meters to be described would have been increased tenfold. Of this number, some that I have made, would, perhaps, have been thought worthy to come into the record. His lecture occurs at an opportune moment, when large projects are afoot for the distribution of electric current from central stations, and when, therefore, electric meters are an imperative necessity.

"Nothing more strikingly illustrates the rapid progress made during the last seven years in the use of electricity, especially in connection with lighting, than the fact that at the beginning of this period there was no such thing as an electric meter, and now there are thousands of electric meters in actual use.

"I remember very well when the details of the Electric Lighting Act of 1881 were under discussion amongst experts, the question whether electric current could be charged for by meter was asked by the Board of Trade, and it had then to be admitted that there was no instrument known that would measure electricity as a gasmeter measures gas. I ventured to express the opinion that although it could not be denied that that was the case, yet the principles upon which meters could be constructed were well known (the principle of electrolysis, as seen in the Daniell's battery and the voltameter, was the best known and most obviously applicable at the moment), and that considering how invariably under such circumstances supply followed closely on the heel of demand, I felt no doubt whatever that as soon as central stations were ready for the meters, the meters would be ready for them. This forecast has been fully verified by the fact; and from the exhibit we have had placed before us to-night, coupled with the indication afforded by the Patent Office of an extraordinary amount of inventive activity concentrated on this subject, it looks almost as if the demand was not merely about to be supplied, but supplied super-abundantly. Meanwhile, although we have got several kinds of meters, all of them reflecting the highest credit on the ingenuity of the inventors, if I single out any one of these as especially deserving of mention for felicity of idea, and exquisite development of the idea, I should certainly have to mention the exceedingly beautiful meter of Prof. Forbes.

"I do not remember how many it possesses of the thirteen qualifications which Prof. Forbes told us should be possessed by an ideal meter, but certainly in his they will count up to a goodly number. I believe I am right in thinking that it was the first of those meters which measure both continuous and alternating currents. How surprisingly the supposed disabilities of alternating currents have melted away in the presence of that all-solving sun—necessity. Now we have not only motor-meters, but also electrolytic meters for alternating currents. Truly, 'All precious things discovered late, to those who seek them issue forth'; and at last I suppose we shall have our ideal meter.

"The things most lacking in the best of the meters shown to-night are want of range and want of simplicity. Range and simplicity were two of Prof. Forbes's thirteen points. To put the first of these into figures, I should say that the range should be at least 1 to 100, instead of 1 to 15 or 20, the range of those meters which so far have the greatest number of the 13 points. In respect of simplicity, and consequently of cost, I think all the motor meters leave much to be desired.

"The experimental meter which Prof. Forbes showed us last, if he can conquer the difficulties of detail that stand in the way of its being made a practical instrument, as he has conquered the seemingly as great difficulties of detail in the case of his windmill meter, would, I think, score most of the thirteen points. Certainly it would have the very great merit of simplicity and wide range, and I earnestly hope that he will persist in the endeavour to perfect it."

* It was pointed out, however, that Mr. Crompton had said that the single clock-meter *was* used. Prof. Forbes was pleased to find he had misunderstood Mr. Crompton.

NOTES ON THE DESIGN OF ELECTRIC MOTORS.*

BY ALBION T. SNELL.

DISCUSSION.

(Concluded from page 102.)

Prof. W. E. Ayrton: In reference to Mr. Esson's very pertinent question, I would say that the lead—that is to say, the actual position of the brushes—was unaltered during the time of the experiment; as a matter of fact it cannot be altered. The Immisch motor does not require any alteration of lead with variable current. The armature was rotated in the different experiments in both ways, so that any advantage that could be obtained by there being a lead would have been obtained for the motor when the armature was rotated one way, and for the dynamo when it was rotated the other, and the numbers that it would be right to take would be the highest values of back E.M.F. in the motor when rotated one way, and the highest values of forward E.M.F. for the dynamo when rotated the other way. The highest values of forward E.M.F. are lower than those of the back E.M.F. when the armature is running the other way. There is no question, therefore, as to the lead being more advantageous in the one case than in the other—the lead was suitable for a machine as a motor and equally suitable for a machine as a dynamo: that answers Mr. Esson's question No. 1. Now, with reference to Mr. Esson's question No. 2. He said on the last occasion "with a current flowing in the same direction through the machine, the armature is revolved, of course, in the opposite direction, the brushes having the tips rounded so that their ends do not turn up." We did not round the tips of our brushes, because that was not necessary, but otherwise we did exactly what Mr. Esson described, and I can only say that we found the result to be as I have already described. I do not mean to say that I neglect for a moment what Mr. Esson has said to-night about self-induction, but he now adds, "you ought to have a correction to make your results equal to mine." All I can say is that we did exactly what is said in the *Electrical Engineer*, and we did not find that in each case $V_1 + CR = V_2 - CR$, as he did, but, on the contrary, we found the $V_1 + CR$ was different from $V_2 - CR$, the result for the dynamo being less than the result for the motor. What he now remarks is, however, perfectly true, that there might have been a term added for self-induction, but does he not rather uphold that self-induction is of no consequence in these machines? He said last time, "I have concluded from this that the effect of self-induction might

* Paper read at the City and Guilds of London Institute Old Students' Association, January 30.

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be neglected." Well, cannot we conclude that the self-induction might be neglected?

Mr. W. B. Esson: No.

Prof. W. E. Ayrton: Of course I do not want to in any way evade the question by a little bit of special pleading, for I value Mr. Esson's suggestions far too highly to attempt to evade them by any mere special pleading, but, if you will allow, I will put down the gist of Mr. Esson's remarks that he has just made. If there be an effect of self-induction, then you may say that in the dynamo $E = V + C(R + r)$, and in the motor $V = E - C(R + r)$. Well, now, if r has an important value, then in order to get E from V, which, of course, is the thing you measure, you ought to add something larger than C R in the case of a dynamo, and you ought to subtract something larger than C R from V to get E in the case of a motor. No doubt, so far, what he says is correct, that we ought to have added something larger than C R to get E in the case of a dynamo, and we ought to have subtracted something larger than C R from V to get the result in the case of a motor. That is, no doubt, true, and that is exactly what Prof. Perry and I pointed out in our original paper years ago, but Mr. Esson, on the other hand, did not follow that course when he made his experiments, and he concluded, to use his own words, that the armature cannot, by any physical possibility, help the field in the motor. I do not think he has proved his point, and possibly he has the same opinion about our experiments. I think, really, that the proper way, with reference to what Dr. Walmsley has written down, is not to express the loss of power in a dynamo or motor as a loss of potential difference, or E.M.F; I think that is rather misleading. I did not make the mistake which Dr. Walmsley thought might have been made. I did not imagine that Mr. Snell meant by E_m what is commonly called the back E.M.F. of the motor. He means a kind of fictitious back E.M.F., but I think it is a mistake to introduce this fictitious back E M.F., this less E.M.F. We do not know that there is any less E.M.F. The proper way is, I believe, to write the thing as we put it in our paper some seven years ago—that is, that the power supplied to the motor, C V, is used up in two ways. It is first divided into two parts, C^2R and Cv. C^2R is the amount of watts that is immediately turned into heat. Apparently, that term may also be divided into two parts—(1) $C^2 R_0$, where R_0 is the ordinary resistance of the armature at rest; and (2) $C^2\,np$, where n is the speed of rotation, and p a term depending on the self-induction of the armature. Lastly, there is Cv, which is *wholly* spent in producing mechanical power. This power is employed partly in overcoming the mechanical friction of the bearings; partly in overcoming the magnetic friction due to Foucault currents; and, lastly, in doing useful work on the tool driven by the motor. That seems to me the proper way to divide up the thing, and not to introduce an imaginary E.M.F., because really we have no proof that there is any such negative E.M.F. existing. A certain number of watts are used up in two ways in a motor, and loss is produced. The heat due to magnetic friction is really of exactly the same kind as the heat due to mechanical friction. In both cases motion is produced, and that motion is employed in grinding metal against metal, and in the other case it is simply used in grinding metal against a possible ether resistance. But in $C^2 R_0$ you have a direct conversion of electric energy to heat. That seems to me better than expressing the loss as an imaginary E.M.F., which is to be subtracted from the true back E.M.F. of the motor. I do not object because I think Mr. Snell meant E_m to stand for the true back E.M.F. for a moment.

Mr. A. T. Snell: No, no.

Prof. Ayrton: I do not object to that; but what I do object to is the introduction of an imaginary loss of E.M.F., which I do not believe exists at all. You use the power of the motor in foolish ways. It is your fault, and not that of the motor, which you are using badly, if by making metal grind against metal, or metal grind against ether friction, you put a brake upon it, and say it is a marvellously bad motor, because the brake has been put on by bad engineering or bad lamination, and so mechanical work is wasted in heat. It may be all one to you whether you have lost the money paid you in receipt of a debt or whether you never received payment, but it is not by any means all the same to the debtor. So it may be all one, as far as the tool is concerned, whether some of the mechanical power developed by the motor has been wasted, or whether that amount of mechanical power was never produced at all; but surely it is very different theory to the electrical engineer, seeing that the deficit must be grappled with in totally different ways.

Mr. Albion T. Snell, in reply, said: Mr. President, and gentlemen, my primary object in writing this paper was to elicit discussion, and I do not think I have failed in that object, for both my mathematics and practical results have certainly been handled quite as roughly as I wished them to be, and I think this debate has given us some very important fresh data which will set us all thinking, and probably enable us practical men to make better machines in the future. But I had also a second reason, and that was to bring before this association a new departure in the method of motor design—that is, that a motor should be designed primarily with reference to the torque, and not with reference to the horse-power. I am sorry to say that this point has been missed, and the discussion has not turned upon what I regard as a very important feature in motor design, but it has rather turned upon the reversibility of the dynamo. My mathematics all through, I should state, are intended more to be of a graphical character than strict mathematics according to the Cambridge view, and I fully agree with Prof. Ayrton that these equations will not stand with mathematicians, but to practical men, with all deference to Prof. Ayrton, I say that this equation *here* is of more importance than *these* equations (Prof. Ayrton's analytical expressions for losses in motor), for the simple reason that we use *these*, but cannot use the others. When we make a motor, the most important point is to know where we lose most of our energy, whether by ohmic resistance, or by friction in the bearings, hysteresis, or Foucault currents. The formula here (board) gives me exactly the loss. I was under the impression that the term $\frac{\text{B.H.P.}\ 746}{n\,c}$ did not appear in Prof. Ayrton's paper, but I am pleased to hear that I have been forestalled in it. I fully recognise the priority of the term. I have had such an amount of criticism that I hardly know where to begin, but I think I will take Prof. Ayrton's speech to commence with. I will first of all say a few words on the design of motors with reference to the current. You know there is a certain current which a motor will work at without undue heating; that we have primarily to determine, and with that current we can do a definite number of foot-pounds per revolution. If a motor is designed to run at, say, 100 volts, and it comes out at 80 volts, it is not of much importance, we merely get less power out of it, but if it has to run at a higher current the motor is useless because it will overheat; and in a dynamo, what we have to look to is the number of volts, because we are going to run lamps at a certain voltage. Thus we do not care so much about the number of amperes, but look primarily to the E.M.F. on the terminals. Mr. Esson has certainly brought forward a very strong view of the opposite side of the main question, but I think that he has rather overlooked certain parts of my paper, particularly in the commencement, in which I practically concede to him almost the whole that he has argued to-night (Mr. Esson, hear, hear). I said distinctly, to begin with, that in large dynamos which were used as motors the same results will not be obtained as with small motors used as dynamos. Now, almost the whole of the experiments which I referred to have been made with machines designed expressly as motors, and not dynamos; but as showing how the armature ran as a motor, compared with the same armature ran as a dynamo, I made some experiments a few days ago on a machine expressly designed as a dynamo. [Formula shown on board.] I take the well-known formula $Ea = K\,\mu\,a\ Nt\,A$, which gives the internal E.M.F. in terms of a constant, the number of turns of wire, the cross-section of the armature, and the value of the magnetism per square inch. The values of the internal E.M.F.'s are severally 381·2 + 302·8 volts, $Nt = 576$, and $A = 59$ square inches. On calculating you will find that the value of the induction in the dynamo is 14 Kapp lines, in the motor it is 14·9. Where does the extra magnetism shown by that formula come from? If the views that Prof. Ayrton and myself have put forward do not account for that extra magnetism, I am fairly at a loss to account for it. I unfortunately, have no mathematical data to prove where this extra magnetism is gained, but it does exist, I am sure, and the experiments that Prof. Ayrton has made with the assistance of his students during the last few days with one of the Immisch motors, fully confirm the experiments that I have made during the last three or four years. Mr. Gümpel has pointed out that although all engines are capable of being used as air-compressors and pumps, yet they by no means make good pumps or good air-compressors. That is obvious, I think, and the same thing really applies to a dynamo and motor. A dynamo may be a good motor, and a good motor may be a very fair dynamo, but it does not follow by any means. Prof. Ayrton made some remarks with reference to self-induction in the armature tending to increase the lead in the dynamo, and decrease the lead in the motor; well, I find that, almost without exception, the lead in a motor is less than the lead in a dynamo, that is, for the same machine, and the difference in machines of the Manchester type is oftentimes so marked that in the dynamo there will be a lead of 30deg., whereas in the motor there will only be a lead of 5deg. Unfortunately, we cannot get inside a dynamo, and we do not know how the lines of force are distributed, but I will try and explain it this way. [Explains on board diagrams showing change of resultant pole with the position of brushes.] The difficulty would appear to be that the position of the resultant axis of magnetism of the armature varies with every alteration of current. If the field, for instance, is increased very much, the pole probably would be very far forward, and right underneath the corner of the pole of the field; but if the current is decreased the chances are it will go back, or *vice versa*. Prof. Ayrton was kind enough to call attention to an oversight in my paper in the expression that I have put for the torque. My equation—it is really in C.G.S. units—is quite correct as it stands, I think. At any rate, I know it appears in all the text-books, and if I am wrong the text-books are wrong. In my paper I dealt with foot-pounds and Kapp lines, and, therefore, I ought to put the constant down; but Dr. Walmsley has been kind enough to write it out, and I will put it on the board. [Equation put on board.]

$$T = \frac{Ca\ Nt\ Za}{2\,\pi} \cdot 00004432.$$

That is the equation I used, but I forget what the constant is. Prof. Ayrton raised another point as to making the magnetic field relatively stronger as the size of the machine is increased. Well, experience seems to point to the fact that as a machine gets larger it is advantageous to increase the size of the field, but I am willing to concede that the principal reason is that of cost. A large armature is very costly, and as a rule, with big machines, the question of weight does not come in, so that it is better to make a small armature with a relatively powerful field than it is to make one with a large armature and a weak field.

Prof. Ayrton: You have no reason except the cost?

Mr. A. T. Snell: Practically none. But I would say that the larger the machine the greater is the leakage, the leakage through space is greater, and the result is that we have a greater difficulty in maintaining a given concentration of magnetism in the armature. Suppose we want to realise, say, 16,000 C.G.S. units in the armature, we should have to put on an increased field of 10 per cent., it may be, over what we should use in the case of a 1 or 2 h.p. machine. I am thinking now of about a 50 h.p. machine. But I can state this most distinctly, that in all cases where a dynamo and motor have to be designed with a given armature, a very much smaller field can be used for the *motor* than for the

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dynamo. I am not sufficient mathematician to give you the reasons for this proportion. If we could thoroughly analyse the very important equations that Prof. Ayrton has just now put on the board, we could find the value of the constants in the usual way, but the matter is practically an extremely difficult one, and that is why I have dealt with the matter in a practical rather than a strictly mathematical manner. With reference to the use of the quantity $\frac{\text{B.H.P. } 746}{n c}$; it is, you can see at once, really an E M.F. The brake horse-power × 746 brings the total quantity into watts. We do not know what the E.M.F. is there at the time, but we do know what the current is, and if we divide by this current we must have a quantity of the order of volts. I prefer to call it the *effective* E.M.F. of the motor, and that is what we want. The theoretical back E.M.F. is not of so much use to us as the actual effective number of volts; if we have that, we have the practical measure of our machine. I would like to cordially thank Mr. Reckenzaun for the interesting speech that he made this evening, for the strong support that he has given to the views that I have been advocating, and I am pleased to find that a dynamo in one case required 60 per cent. more speed than it did as a motor. This thoroughly bears out the results of my experience. I shall be very pleased to take the hints that have been given to me this evening about the alterations in the equations and so on, and I am also obliged to Mr. Kilgour for his remarks upon the subject of efficiency. I did not quite catch the pith of his remarks, but I think I know what he meant. The diagram is for a Sprague motor, and I hope Mr. Sprague will pardon me for saying that his motor is not efficient, but the curve of the diagram shows it thus. [Diagram on board explained.] The machine should be designed so that although we do not take maximum work out of the motor, the work is done at a more efficient part of the curve. This is a most important point in the design. I hope before long to have an opportunity of putting before you what I would call the curves for a normal Immisch motor. I have only to thank you for the kind manner in which you have received my paper, and I shall have very much pleasure in taking advantage of the criticisms that have been so liberally given.

COMPANIES' MEETINGS.

TAUNTON ELECTRIC LIGHTING COMPANY.

The second annual general meeting of the shareholders of the Taunton Electric Lighting Company, Limited, was held at the Castle Hotel, Taunton, on Monday evening. Mr. W. H. Fowler, J.P., the chairman of the directors, presided.

The **Chairman** read the following report and balance-sheet: "The number of shares allotted is 951, on which the sum of £4,750 has been received. The accounts for the year show a profit of £355. 18s. 2d. Your Directors recommend that a dividend of 6 per cent. be paid free of income-tax. This will take £272. 0s. 5d. The balance carried on for a reserve and depreciation account, including the amount from 1887, will be £207. 13s. 9d. In addition to the Taunton business, the Company has carried out temporary installations in Bristol, Bath, and Exeter. Deputations from various places have visited Taunton during the past year, for the purpose of inspecting the Company's works, and the lighting arrangements of the town; the general testimony being that it is the most successful installation in central station lighting yet carried out in the United Kingdom. The machinery has been maintained in excellent working order, those portions of it which are continuously wearing out being made good and charged to income account. The present engines are rather extravagant in their consumption of fuel; your Directors therefore recommend that, as the demand for private lighting is rapidly increasing, engines of the highest possible efficiency should now be put down, using the present engines as duplicate plant only. This will effect a saving of nearly £200 per annum in coal, water, and oil. It is desirable also to largely increase the electrical plant to enable your Directors to cope with the increasing business, and they therefore propose to offer, at par, the remaining share capital of the Company. Should the applications for shares exceed the number offered, the present shareholders will receive priority of allotment in proportion to the number of shares they now hold. Three of the Directors retire by rotation, and are eligible for re-election—namely, Messrs. Bale, Withycombe, and Potter. The auditor, Mr. Albert Goodman, retires, but is eligible for re-election, and offers himself accordingly. Balance-sheet: Capital Account—Receipts—To share capital—954 shares at £5 each, £4,770; less calls unpaid, £20; total, £4,570; debentures, £3,000; balance, £129. 0s. 10d.; £7,879. 0s. 10d. Expenditure: Plant, machinery, etc, including business taken off, apparatus, formation, and preliminary expenses, £7,879. 0s. 10d.; balance brought down, £129. 0s. 10d. Income Account: Income—Rents for lamps; electrical apparatus, etc., sold; installations carried out, £2,471. 14s. 10d.; stock in hand December 31, 1888, £340. 19s. 10d.; £2,812. 14s. 8d. Expenditure: New apparatus and renewals, £541. 17s. 10d.; wages and salaries, £529. 18s. 3d.; hire of plant, etc, for temporary installations, £261. 19s.; Directors' fees, £37. 16s.; interest on debentures, £146. 1s. 9d.; bank interest, £30. 3s., making with other items a total of £2,305. 1s. 8d.; stock in hand December 31, 1887, £151. 14s. 9d.; balance, being profit, £355. 18s. 3d.; £2,812. 14s. 8d. Assets—rents and accounts for installations, due, £1,203. 6s. 6d.; stock in trade, £340. 19s. 10d.; balance from capital account, £129. 0s. 10d.; £1,673. 7s. 2d. Liabilities—Balance due to bank, £617. 19s. 1d.; liabilities, £575. 13s. 11d.; balance, £479. 14s. 2d.; £1,673. 7s. 2d. Profit and loss account—profit, year ending December 31, 1887, £315. 15s. 5d.; balance brought down, £123. 15s. 11d., profit, year ending December 31, 1888, £355. 18s. 3d.; £479. 14s. 2d. Dividends (5 per cent.) paid for 1887, £191. 19s. 6d.; balance, £123. 15s. 11d.; total, £315. 15s. 5d.; dividend at 6 per cent., £272. 0s. 5d.; balance carried forward, £207. 13s. 9d.; £479. 14s. 2d. Cash account—receipts—balance at the bank, December 31st, 1887, £376. 8s. 9d.; receipts—capital account—shares, £4,750; less, December 31, 1887, £4,365, £385; income account, £1,760. 3s. 10d.; balance due to bank, £617. 19s. 1d.; £3,139. 11s. 8d. Payments—Cheques not presented, December 31, 1887, £364. 12s. 11d.; liabilities due December 31, 1887, £92. 13s. 8d.; expenditure—capital account, £7,879. 0s. 10d.; less, December 31, 1887, £7,118. 3s.; £760. 17s. 10d.; expenditure—income account, £2,305. 1s. 8d.; less, unpaid, £575. 13s. 11d., £1,729. 7s. 9d.; dividends paid, £191. 19s. 6d.; £3,139. 11s. 8d."

The **Chairman**, in proposing the adoption of the report, said it was a very satisfactory thing that at the end of their second year they were able to pay an increased dividend, and at the same time to make proper provision for depreciation of plant, and for any extraordinary expenditure that might come upon them. They had carried forward a sum of £207. 13s. 7d., and as the machinery was kept at its highest efficiency he thought they could consider they were fully justified in paying an increased dividend. At the same time it was absolutely necessary to enlarge their plant, and they would be unable to do so unless they had further capital from the general public. If others were prepared to back him up, he would put a further sum of £500 in the Company, because he was fully satisfied that the thing would be a success, provided they made it large enough to meet the demands of the general public. He thought they were all greatly indebted to their managing director (Mr. Massingham) for the way in which he had attended to the Company's interests and the supervision of the works. He then moved that a dividend of 6 per cent. be paid free of income-tax to be payable on the 13th inst.

Mr. Lance seconded the report.

Mr. Massingham, in moving the re-election of Mr. Bale, said it gave him great pleasure to ask the shareholders to re-elect that gentlemen, because Mr. Bale was a man of very enlightened views. He showed that by becoming a shareholder in the Electric Lighting Company, although he was at the same time a large shareholder in the rival concern in the town (the Gas Company), he had seen that there was plenty of room for the electric light in Taunton, and he had supported that company from the beginning. Referring to the report he said all would agree with the Chairman that is was a very satisfactory and encouraging one, because they would find that the revenue had increased by 45 per cent., and owing to that increase they were able to pay an additional one per cent. dividend. He thought it very probable that next year they would be able to pay 7 per cent. dividend because there was a large number of customers awaiting to be supplied, a demand which could not be met at present owing to the smallness of the plant. Until they had got better and larger plant they would not be able to supply all that was demanded. They started three years ago with one dynamo, now they had six, and larger ones were required. New ones would be provided, and the old ones still be used when necessary, in case, for instance, of a breakdown. Breakdowns in Taunton hitherto had fortunately been very "few and far between." Everyone knew that this, like all other inventions, were liable to accidents. Breakdowns occurred in older and well-tried concerns. He instanced the case of a town in Wales, where the whole town was thrown into complete darkness owing to an explosion in the gas works. He believed that theirs was the most satisfactory installation in England. Among other gratifying features was the proposal to largely increase the plant and lay down more efficient engines. The engines now used had given satisfaction, but they were not of the highest and best type obtainable, and while they were very serviceable when the supply was not so great, they had reached a state of success that enabled them to buy better ones. He thought the purchase of new machines would result in the saving of £200 a year, and that meant a dividend of 4 per cent. on the capital. He went on to state that the greater the supply the cheaper would be the cost of the production, and as the demand increased they would, doubtless, be able to reduce the price to the consumer. He was pleased to hear that the Chairman had intimated his willingness to purchase other shares in the Company, and he thought from the applications that they had had they would have little difficulty in raising the capital they proposed. One matter he wished to refer to was the standards from which the arc lamps were suspended in the streets of Taunton. He thought the town authorities ought to erect better ones now, after the pattern of those to be erected at Bath. The present standards were erected only as temporary ones while the electric light was being tried as an experiment. The standards answered their purpose very well then, but now that the electric light had passed from its experimental stage and was proved to be a success, he thought permanent ones should be erected. He hoped the Corporation would see the advisability of providing more suitable standards.

Mr. A. Chapman seconded the re-election of Mr. Bale. He had no doubt that Mr. Bale would continue in the future to be the same useful member on the Board of Directors that he had been in the past.

The motion was carried.

Mr. Bale returned thanks. In doing so, he said the success of the undertaking in which they had embarked had been secured in a great measure by the very conscientious and unremittent attention which the Directors generally had given to the work. It had been a pleasure to him to work with them.

Mr. A. Steevens proposed the re-election of Mr. Withycombe. He said that Mr. Withycombe had shown his confidence in the undertaking by having his hotel lighted at considerable expense by electricity. He was sure, from what they knew of him in all relations of life, and especially as a business man, it was highly desirable that he should be re-elected on the Board of Directors.

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Mr. Bale seconded the motion, which was carried, and **Mr. Withycombe** suitably responded.

Mr. A. Goodman proposed the re-election of Mr. Potter, which was seconded by **Mr. Down,** and carried.

Mr. Potter, in returning thanks, said they might congratulate themselves on the fact of their continued existence. The report presented at that meeting went to discredit the prognostications made at the birth of the electric light movement that it was such a weak and sickly concern that they could not possibly exist. Many of their kind friends, with the kindest possible intentions, advised them not to invest in that Company, and have nothing to do with the work whose existence was so precarious. There were some grounds for the fears of their friends, perhaps, because some previous undertakings of the kind had not had a very prosperous life. Their Company, however, had proved beyond a doubt that the new illuminant could be made a prosperous, good, and paying concern. There was another thing they might congratulate themselves on, and that was that a company that had adopted the Thomson-Houston system never ended in disaster or disgrace. Although the present system was not a perfect one—it was not claimed for it that it was—they claimed that it was the most perfect system yet introduced into this country, and they had proof of this in the fact that larger towns than Taunton, such as Exeter and Bath, had adopted the same system with success. That it was successful in Taunton no one would attempt to deny now. The first year of their existence they not only claimed but fairly earned a dividend of 5 per cent. That dividend was not taken out of the share capital, as had been alleged, but had been fairly obtained from the profits. This year they had been able to declare a dividend of 6 per cent., an event unprecedented in the history of electric lighting in this country. Their position, now, was just this. They had outgrown their premises, and they had an increased demand for the light, which rendered it necessary that they should seek larger premises, and lay down additional plant, and to do this it was necessary that the remaining share capital should be obtained. If this were done, there was every probability of the dividend being increased next year. But their prosperity had not been purchased by loss to any other company. So far as he was aware the introduction of electric light had been attended by nothing but good. It had unquestionably benefited the town. It had earned for the town a reputation which nothing had previously given it; it had drawn public attention to the town, and this had resulted in the people finding out what a desirable place of residence it was, and he believed that at the present time there were fewer villa residences to let in the neighbourhood of Taunton than there had been for the last 10 or 15 years. He hoped, in conclusion, that every shareholder would secure the additional capital being taken up, and he was sure that in the future, as in the past, success would be assured.

Mr. Bale proposed the re-election of Mr. Goodman as auditor, which was seconded by **Mr. Massingham.** The latter thought the Company had been exceedingly fortunate in securing Mr. Goodman as auditor. From the fact that Mr. Goodman held the position of Director on the Taunton Gas Company he was exceptionally well qualified to audit the accounts. If Mr. Goodman were their bitterest enemy instead of their greatest friend, he could not be more careful and searching in looking over the accounts.

The resolution having been carried, **Mr. Goodman** returned thanks and spoke of the advantages that would accrue from the increased capital being obtained.

Mr. A. Goodman moved a vote of thanks to the Directors, which was seconded by **Mr. Waldegrave,** and responded to by the **Chairman.**

Mr. Potter moved a vote of thanks to the Chairman, **Mr. A. Lewis** seconded the motion, and the **Chairman** responded, this bringing the meeting to a close.

ANGLO-AMERICAN TELEGRAPH COMPANY.

The ordinary general half-yearly meeting of the Anglo-American Telegraph Company, Limited, was held on Friday at Winchester-house, Old Broad-street.

Viscount Monck, who presided, in moving the adoption of the report, said that during the past half-year they had had, as the shareholders were aware, a good many repairs effected in their cables. They had been executed entirely by the Company's own steamer, and, therefore, at first cost. Their deep-sea cables had been all in good order except the original French cable of 1869, upon which the Company had had very considerable repairs to make. That was the oldest cable now transacting business in the Atlantic, and it was put into thorough working order. As to the expenditure which had been incurred, independently of repairs and renewal of cable, the board had endeavoured to reduce it as much as possible, and if the shareholders would take the trouble of comparing two or three of the annual reports and examining the details of the outlay, they would find that it was but a very small portion of the expenditure over which the Directors could exercise any direct control. They had debited themselves with £2,000, the estimated cost of the law suit now pending between the Company and the Paris and New York Telegraph Company—an item which would not again appear in the accounts. As to the Company's income and prospects, if they did not give rise to any effusive jubilations, they were at all events more satisfactory than had been the case at recent meetings. He then referred at some length to the experiment of a sixpenny word rate, which, he said, had been tried for a year and proved conclusively to everyone concerned that in the present condition of Atlantic telegraphy such a tariff would not pay. They had therefore increased the rate to 1s. a word. The experience they had had of the latter rate was not sufficiently extensive to enable them to form an opinion as to whether it would be satisfactory or not; but this he could say—that up to the present time it had not been unsatisfactory. At any rate, whatever might be the result, he hoped that by the exercise of moderation and forbearance to their adversaries they would ultimately fix on a tariff which, without bringing to the shareholders such large returns as would induce further competition, would yield a moderate and remunerative dividend on the money they had invested in the concern.

The **Marquis of Tweeddale** seconded the motion.

Mr. Smith (York), **Mr. Jackson,** and **Mr. Guesdon,** congratulated the Directors on the favourable condition and prospects of the Company, and on the memorandum of agreement which had been entered into between the Company and its rivals, whereby peace was established for at least 12 months, with the probability at the end of that period of a permanent working understanding being arrived at.

The **Chairman,** in reply to a question, said he could not state what would be the probable "life" of the 1869 cable; but wherever it had been picked up for repair in favourable conditions at the bottom of the sea, it was found to be as good as it was when originally laid.

The report was adopted, and the retiring Directors and Auditors were re-elected.

GERMAN UNION TELEGRAPH AND TRUST COMPANY.

The eighteenth and final ordinary general meeting of the German Union Telegraph and Trust Company, Limited, was held on Wednesday last at Winchester House, Sir James Anderson presiding.

The **Chairman** said that he was somewhat disappointed that the hopes held out at the last meeting of the shares getting very nearly par had not been fulfilled. Since then, in December, they had broken the cable, the cost to repair which had been no less than £7,684, which, of course, had to come off the payment on shares. He had been startled to find the money sent over to them in marks, and an allowance of 5d. in the pound had to be agreed to in consequence. They would receive, he believed, £7. 6s. per £10 share, and he hoped they would ultimately get about £2. 4s. 9d. more, to make a total of £9. 10s 9d.—that is, if affairs turned out as they expected. As this was the final meeting he had nothing further to do than to move the adoption of the report and balance-sheet for the period ending January 25 last, which showed receipts amounting to £754. 5s., which, with a balance of £156. 3s. 5d. brought forward, made a total of £910. 8s. 5d., the expenses of the same period being £909. 9s. 7d., of which sum £750 was provided by the German Union Company of Berlin, the balance to be handed to the liquidators.

Mr. Hermann Gustav Erichsen seconded the motion, which was carried.

The **Chairman** then said he was sorry the German Government had taken the business from them, but all they could do was to submit, although he believed the Company would otherwise have been successful.

An extraordinary general meeting was afterwards held, when the **Chairman** moved, and **Mr. Erichsen** seconded: "That the resolution passed by the extraordinary general meeting on January 22, 1889, 'That this company be wound-up voluntarily,' be, and the same is hereby confirmed."

The motion was carried without discussion, with one dissentient.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the past week amounted to £4,796.

Great Northern Telegraph Company.—The receipts for the month of January amounted to £22,400.

West Coast of America Telegraph Company.—The traffic receipts of this Company for the month of January amounted to £6,125.

Eastern Telegraph Company.—The receipts of this Company for January were £65,835, as against £56,164 for the same period of 1888, or an increase of £9,671.

Eastern Extension Telegraph Company.—This Company's traffic receipts for the month of January were £41,820, as against £39,878 for the same period of 1888.

Western and Brazilian Telegraph Company.—The receipts of this Company, after deducting the "fifth" payable to the London Platino-Brazilian Company, were £3,691.

Direct Spanish Telegraph Company.—The receipts of this Company for the month of January are estimated at £1.880, as against £1,943 in the corresponding period of last year.

Telegraph Construction and Maintenance Company.—Including the interim dividend of 5 per cent., the Directors of this Company propose to pay 20 per cent. for the past year.

West India and Panama Telegraph Company.—The receipts of this Company for the half-month ended January 31 show a decrease of £509, as compared with the corresponding period.

Taunton Electric Lighting Company.—A dividend of 6 per cent. has been declared, as against 5 per cent. last year. The Directors ask for more capital in order that they may give attention to the question of domestic lighting.

National Telephone Company, Limited.—The Directors of this Company have declared a dividend for the past half-year at the rate of 4 per cent. per annum, leaving a balance to be carried forward of £10,399, of which £3,500 is set aside against an outstanding claim.

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London and Provincial Lighting Company.—Mr. Justice Chitty has appointed Mr. Lionel H. Lemon, chartered accountant, official liquidator of the London and Provincial Electric Lighting and Power Generating Company, Limited, in place of Mr. W. Lott Grimwade.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of the Cuba Submarine Telegraph Company during January was 3,922, estimated to produce £3,100, against 4,064 messages, producing £3,366. The traffic receipts for October, estimated at £3,300, realised £3,316.

Crompton and Co., Limited.—The Directors of this Company, at their meeting held on the 31st ult., declared an interim dividend of 7 per cent. per annum upon the preference shares of this Company for the five months ending December 31 last. They have also decided to pay at the same time the 4 per cent. interest to same date upon the amounts paid in full in advance of calls.

Companies of the Month.—The following electrical companies were registered during the past month :

Electro-Galvanic Machine Company, £1 shares	3,500
Miners' Lamp Electric Lighting Company, £5 shares	3,000
Maxim-Weston Electric Company, 3s. shares	75,000
Newcastle-upon-Tyne Electric Supply Company, £5 shares...	50,000
Newcastle and District Electric Lighting Company, £10 shares	50,000

India Rubber, Gutta Percha, and Telegraph Works Company, Limited.—The report of the Directors of this Company for the year ending December 31 last show the net profit for the past year to be £57,157. 14s. 2d. Adding £9,530. 3s. 5d. brought forward, and deducting £20,800 interim dividend paid in July, there remains a disposable balance of £45,887. 17s. 7d. The Directors recommend the distribution of a dividend of 10s. per share, free of income-tax, amounting to £20,800, making, with the interim dividend, a total payment for the year of 10 per cent., and leaving £25,087. 17s. 7d. to be carried forward. The Company's general business continues to increase; but competition is as keen as ever, and only a low rate of profit can be made. The submarine cable work of the year has consisted of several items of small amount. The works are now occupied in the manufacture of about 800 miles for the Eastern and South African Telegraph Company, to be laid in May on the West Coast of Africa, in extension of the West African Telegraph Company's cables manufactured and laid by this Company. The Company's works and machinery are in efficient working order. Mr. Scott and Mr. Henderson, the Directors retiring by rotation, offer themselves for re-election. The Auditor, Mr. Weise, retires, and is re-eligible.

PROVISIONAL PATENTS, 1889.

DECEMBER 11, 1888.

18,035A. **An improved ampere gauge and connections, parts of which are applicable to other electric appliances.** Sir William Thomson, 115, St. Vincent-street, Glasgow. [Note. This application having been originally included in No. 18,035, dated 11th December, 1888, takes, under Patents Rule 23, that date.]

18,035B. **Improved apparatus for continuously measuring and recording potentials or currents.** Sir William Thomson, 115, St. Vincent-street, Glasgow. [Note. This application having been orginally included in No. 18,035, dated 11th December, 1888, takes, under Patents Rule 23, that date.]

18,035C. **Apparatus for regulating electric potentials or currents.** Sir William Thomson, 115, St. Vincent-street, Glasgow. [Note. This application having been originally included in No. 18,035, dated 11th December, 1888, takes, under Patents Rule 23, that date.]

JANUARY 28, 1889.

1480. **Electric meters and motors.** Arthur Wright, George Herbert Alderton, and George Joseph Philpott, 3, Clement's-road, Preston Park, Brighton.

1500. **Applying electric light to cycles.** Richard Martin Presland, Lyme-grove, Mare-street, Hackney, and Ernest Henry Glover, 40, Selborne-road, Walthamstow, Essex.

1510. **Improvements in electrical transformers.** William Morris Mordey, 46, Lincoln's-inn-fields, London, W.C.

1535. **Improvements in the construction and working of dynamos.** Illius Augustus Timmis, 2, Great George-street, Westminster, S.W.

1537. **Improvements in or relating to electric incandescent lighting.** Alfred Julius Boult, 323, High Holborn, Middlesex. (Stefan Doubrava, Austria.)

JANUARY 29.

1573 **Certain improvements in electro-magnetic transmitters (port-electrics).** Cecil Urquhart Fisher, 1, Furnival-street, Holborn. (John Thomas Williams, United States.) (Complete specification.)

1611. **Improvements relating to multiplex electric telegraphy.** Mark Wesley Dewey, 45, Southampton-buildings, London. (Complete specification.)

JANUARY 30.

1673. **Improvements in the construction of secondary batteries.** Gustave Philippart, 6, Bream's-buildings, London, E.C.

1677. **An automatic electric switch.** George Herbert Whittingham, 323, High Holborn. (Complete specification.)

JANUARY 31.

1757. **A new or improved automatic coin-freed machine for giving electric shocks.** Joseph Mason, 76, Chancery-lane, London, W.C.

1768. **Automatic circuit changer for electric currents.** Philipp von Hertling, 89, Chancery-lane, London, W.C.

1775. **Means and appliances for holding electric accumulators on vehicles.** Michael Radcliffe Ward, 9, Warwick-street, Regent-street, London.

FEBRUARY 1.

1823. **Improvements constituting a combined translator and indicator for telephonic purposes, part of such improvements being applicable also, either in such combination or otherwise, for preventing or lessening induction between translators placed near together.** Alfred Coleman and Hubert Fielden Jackson, 55 and 56, Chancery-lane, London.

1827. **Improvements in telephones.** Max Salmony, 45, Southampton-buildings, London.

1839. **A combination electric arc light.** Charles Wells, 22, Southampton-buildings, Chancery-lane, W.C., Middlesex.

1846. **Improvements in the application of heat produced from liquid hydro-carbon and water burners to the production of light and electricity, and in apparatus for this purpose.** William Boggett, 34, Southampton-buildings, London, W.C.

1850. **Improvements in the method of constructing the armatures of dynamo-electric generators and motors.** Walter Thomas Goolden and Henry Willock Ravenshaw, 46, and 47, Temple Chambers, E.C.

FEBRUARY 2.

1855. **An improvement in insulators and appliances for fixing, tightening, and retaining telegraph wires, electric wires, and other wires or ropes.** Herbert Hobson, Shepherd Rushton, and Alfred Wood, 111, Long-street, Middleton, near Manchester.

1861. **Improvements in and connected with galvanic batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

1865. **Improvements in telephone apparatus to be designated as a telephone receiver rest.** Joseph Bushell and George William Hughes, 5, Harrington-street, Liverpool.

1892. **Improvements in electric motors and means for regulating the same.** Alfred Julius Boult, 323, High Holborn, Middlesex. (Lemuel W. Serrell and Harvey L. Lufkin, United States.) (Complete specification.)

1903. **Improvements in electric motors and electric meters.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London, W.C.

1904. **Improvements in dynamos suitable especially for use as motors.** Sebastian Ziani de Ferranti and Francis Ince, 24, Southampton-buildings, London, W.C.

1911. **Reducing the difference of potential between the component wires of coils over which alternating electric currents flow or pass.** Walter Thomas Goolden and Henry Willcock Ravenshaw, 46 and 47, Temple Chambers, Temple Avenue, E.C.

SPECIFICATIONS PUBLISHED.

1888.

249. **Measuring electric currents, &c.** Roe. 8d.

1024. **Electric cells.** Pyke and Barnett. 8d.

3515. **Telephonic apparatus.** Collet. 8d.

9254. **Controlling devices operated by the thermic effects of electric currents.** Drake and others. 8d.

14,772. **Measuring electric currents.** Redfern. (Brillié). 8d.

17,668. **Electric railways.** Short. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	4
12 Feb.	2/0	— fully paid	5	5
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	19
......	...	House-to-House	4½	—
30 May	2½%	Oriental Telephone	11	½
26 April	4/0	Reuter's	8	7½
......	...	Swan United	3½	2½
12 July	12/0	Telegraph Construction ...	12	43
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	13

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NOTES.

Nuremberg.—The firm of Schuckert and Co. has been formed into a limited company.

Electric Dogcart in Rome.—An electric dogcart belonging to a rich American is to be seen running in the streets of Rome.

Elmore's Copper.—It is expected by the inventors that Elmore's process will work a revolution in the copper trade, almost as great as Bessemer's in the steel trade.

Royal Institution.—A paper will be read to-day, Friday, at the Royal Institution, Albemarle-street, at 9 p.m., by Prof. A. W. Rücker, on "Electrical Stress."

Books Received.—Reynier on the "Voltaic Accumulator," translated by J. A. Berly (Spon); "The Elementary Principles of Electric Lighting," by A. Campbell Swinton (Crosby Lockwood).

Farnborough.—The Empress Eugénie has just had telephonic communication established between her residence and the stables. The work was satisfactorily carried out by Mr. Julian, of Basingstoke.

Concert.—The next concert to be given by the Electro-Harmonic Society will be held in the Banquet Room of the St. James's Hall Restaurant, on Friday, February 22, when an excellent and varied programme will be given.

The Ice Carnival.—Arrangements are being made by Mr. Whiteley, the director-general of the proposed ice carnival at the Royal Albert Hall, in March, to light the hall with electric light, which will give the snowy scene a novel and beautiful effect.

Another Consolidation.—The Westinghouse Company have made another annexation, and the interests of this company are now identical with those of the United States Electric Lighting Company. There are now practically only four strong electric light companies in the field in the United States.

Electric Defence against Burglars.—Owing to the recent burglaries, the Hornsey Local Board has given permission for the police authorities to be connected to the telephones belonging to the Board now used for fire alarm purposes, thus giving direct communication at various points with the police stations.

Reading.—The plant at Reading is being put down by Messrs. Laing, Wharton, and Down on a site known as the "Island." It will consist of two Thomson-Houston dynamos of twenty 1,200 c.p. arc lamps, driven by twin 9 h.p. nominal Armington and Sims' engines. The boilers are 25 h.p. in duplicate.

Backing Electric Cars.—One of the incidental advantages experienced with electric traction for tramcars, is the ability to easily back and take up passengers. This is a point which is much appreciated by ladies and elderly persons, and is in reality an advantage in point of time to the company in picking up passengers.

Coal-Dust Furnace.—Perret's patent furnace for burning coal-dust alone in boiler furnaces is being brought out by Messrs. Bryan, Donkin and Co., Bermondsey. The firm have some 140 at work, and when coal-dust can be obtained it affords a very cheap method of obtaining power. Mr. D. K. Clark, M.I.C.E., has published a favourable report upon the furnace.

School of Electricity at Columbia.—The Columbia College (U.S.) trustees have determined to establish a post-graduate department in electrical engineering for practical work combined with theoretical training. The department will begin in a small way at first. An instructor and assistant instructor in electrical engineering will be appointed. The situation will probably be in New York city.

Electrical Church Bell.—A substitution of church and school bells is introduced by Messrs. Watt, Winnall, and Co., Atlas Works, Stepney, the action of which is electrical, and does away entirely with bell-ropes. The armature is so arranged that a stroke first one side and then the other is given in the same way as ordinary bell-ringing. The bell is also useful for factories and railway bells.

Newcastle.—Two companies have applied for permission to the Newcastle Town Council to lay down wires for electric lighting purposes. It was virtually agreed as to the arrangements between them, but details have yet to be settled after a joint meeting between the respective companies and the committee. A report will be drawn up and printed, and discussed at the next meeting of the Council.

Resume of the Brussels Exhibition.—We have received, by the courtesy of M. Bandsept, who acted as engineer-in-chief to the electrical section, a very neat and useful little book, being a *résumé* of the electrical exhibits, section 47, of the Brussels Exhibition of last year. The various exhibits and novelties are described in detail with abundant information, and illustrations are given of the principal apparatus.

Students' Meeting.—A meeting of the students of the Institution of Electrical Engineers was held last Friday evening, Mr. J. Rance, jun., A.I.E.E., in the chair. A paper was read by Mr. F. L. Horn on "Insulation Resistance," dealing with some of the practical difficulties in obtaining good insulation on electric light circuits. A discussion followed, in which Messrs. G. H. Nisbett, R. W. Paul, and Rance took part.

Visit of American Engineers.—One hundred and seventy members of the American engineers have pledged themselves to a visit to England during the Paris Exhibition, and arrangements are practically completed with the various societies in England for their entertainment. Those who have engineering concerns likely to be special objects of interest would do well to notify their permission or request of a visit to our American visitors.

"Star" Light.—The *Star* has adopted electric light as a novelty on its paper-distributing carts. A small storage battery is placed in the boot of the gig, and communicates with a 10-c.p. incandescent lamp fixed at the top of a rod which rises 3ft. or 4ft. above the highest point of the vehicle. Altogether 32 carts are employed in distributing the paper. Each accumulator carries a supply of electricity sufficient for two days, and is charged on the premises of the newspaper.

Perth.—Messrs. P. and P. Campbell, of the Perth Dye Works, have had two new alternating current dynamos fitted in connection with the electric lighting of their works, for the purpose of securing light in case of a breakdown of the large engines. Eight extra lamps have also been fitted up in the dyehouse. Messrs. Campbell have now 40 arc lamps and 100 incandescent lamps in their works. The dynamos and lamps were fitted by Messrs. Normand and Sons, Limited, Glasgow.

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Austria.—A new large central station is to be erected by Ganz and Co. at Marienbad, Austria, on the Zipernowski system. The station will be near the railway station, and current will be sent 1½ miles to transformers. Two 50,000 watt machines are to be employed. There will be 35 arc lamps of 12 amperes, and 100 incandescent lamps of various candle-powers for the public streets. After midnight, the incandescent lamps only will be lighted. For private lighting there will be current for 2,500 incandescent lamps.

A Useful Fault.—A good tale of masterly inactivity comes from South Australia. A man who had got lost in the bush wandered about for four days without finding his way, when, worn out with fatigue, he came across the telegraph line. If he only knew the Morse alphabet and had an instrument! He despaired, but suddenly the brilliant idea came into his head to cut the wire and camp on the spot. A dead break was naturally at once found on the line, and telegraph linesmen were sent out to discover the fault, and happily came upon the wanderer in time to save his life.

A Small Motor.—M. Trouvé has made for experiments on aerial navigation a small motor, weighing 0·090 kilogramme, which can do two kilogrammetres of work per second, and can be contained in a cube of three centimetres' edge (1¼in.) This motor, which is made entirely of aluminium, raises itself to a height of 22 metres in a second. A one-horse motor constructed on the same plans would weigh 3·5 kilogrammes (7¾lb.). These electric motors will afford facilities for the study of the efficiencies of screw-propellers for aerial navigation, and of experiments on the best form to give them.

Electric Type Matrix.—Mr. Capehart, of Minneapolis, has brought out an electric machine which acts as a typewriter in a novel way—to produce stereos direct for printing. The machine works upon dry cardboard, and stamps upon this a perfect matrix for casting a plate, "justified" and ready for working. The movements are electrical, and it is stated that it prints faster than three good printers, besides greatly saving in type and in distribution. Thirty of these machines are being made, it is stated, at Minneapolis, and a trial of printing a newspaper direct from the matrix is to be made. It will be interesting to inspect a paper printed by this machine.

Lighting Railway Tunnels.—A new era in railway engineering has possibly been inaugurated by the complete lighting of the Hoosac Tunnel with incandescent lights. There are 650 16-c.p. lamps employed for this purpose on the Westinghouse system, with 40 miles of lead-covered cable. The railway company's objects are to afford greater safety to the travelling public, as well as to facilitate workmen's operations in the tunnel. The wiring is arranged in twenty sections of 50 volt lamps on transformer circuits. For long tunnels, such as the Mont Cenis and others, this method of lighting may prove sufficiently advantageous to be adopted for supplying light underground along the route.

The Electric Omnibus.—Further runs have been made with Radcliffe Ward's electric omnibus. This time it has gone through the City, Queen Victoria-street, Lombard-street, Cheapside, etc., to Oxford-street, and down Regent - street to the depot. Again, on last Friday, a run was made — not in the early morning, but in the thick of the forenoon traffic, through the busiest streets, taking its place amongst other vehicles, steering in and out in the ordinary daily traffic. The electric omnibus in the ordinary streets has now become the subject of an illustration in the illustrated papers. Mr. Ward and his electric bus are rapidly getting a European reputation.

St. Martin-in-the-Fields Vestry.—A letter was read from the Board of Trade at the Vestry meeting on the 7th inst., stating that their attention had been called to the fact that certain streets in this parish have been broken up for the purpose of laying electric mains by persons having no statutory powers under the Electric Lighting Acts, and that such proceedings materially increase their difficulties in dealing with applications for the privilege of supplying electricity, and that they are advised that the proceedings are illegal and undesirable. This letter was referred to the Parliamentary Committee. The Vestry was then made special, according to notice, to consider an application from the House-to-House Electric Lighting (Storage) Company for consent to a provisional order. This was granted.

Telegrams from the Continent.—In the course of the debate in the Berlin Reichstag last Friday upon the estimates of the German Postal and Telegraph Departments, Dr. von Stephan, the Postmaster-General, declared that by agreement with the British Government the *grundtaxe* of 40 pfennige hitherto charged on telegrams to England would be abolished from April 1 next, and the word rate reduced from 20 to 15 pfennige. Dr. Stephan added that direct communication would be established between the central telegraph offices in Berlin and London, and that 14 wires would be available. Negotiations having a similar object in view were proceeding with Holland and Belgium, and the establishment of direct communication between Hamburg and Liverpool was also contemplated.

Light Without Heat.—Mr. E. G. Acheson writes to the *Electrical World* pointing out that a patent was issued to him on December, 1887 (calectric generator), on the production of electric currents from heat energy, by causing the heat to enter an electric conductor, and therein acting upon it by changing lines of magnetic force, and will fully cover the production of electric energy, even up to such rapidity of oscillations as have been found necessary for light waves. There is, he thinks, no doubt but that this is the method by which energy will be caused to pass from point of production to point of consumption, and that, too, in the near future. He does not wish to discourage experiment by others, but mentions that patents on these oscillatory motions are even now broadly covered, and form the basis of continual experimental work and researches.

Prizes for Electric Light Motors.—The Council of the Society of Arts, on report of the judges —Prof. Kennedy, F.R.S., Dr. John Hopkinson, F.R.S., and Mr. Beauchamp Tower—awarded one of the society's gold medals to each of the following competitors: In Class A ("Motors in which the working agent is also produced"), for steam-engines, Messrs. Davey, Paxman, and Co., Standard Iron Works, Colchester, for an 8 h.p. compound portable engine: In Class B ("Motors to which the working agent must be applied") for engines worked by illuminating or other gas: British Gas-Engine and Engineering Company, for a 6 h.p. nominal Atkinson "Cycle" gas-engine; Messrs. Crossley Bros., Limited, for a 9 h.p. nominal "Otto" gas-engine; Messrs. Dick, Kerr, and Co., for an

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8 h.p. "Griffin" gas-engine. The report of the judges in detail will be published shortly.

Alternating Tramway Motors.—A system of distribution for street tramways is proposed by Mr. W. L. Silvey, of Lima, Ohio, for use with alternate current motors. In this, high-tension currents of 2,000 volts are used with transformers to reduce the pressure to 40 or 50 volts, and by this means the advantage of the series and the parallel systems are combined. The system is an overhead one, and the transformers are placed either on posts along the track, with the carriers or trolleys connecting to the low-tension wires, or with transformers on the roof of each car, with the carriers connecting to the high-tension car. The low tension on the motors makes the matter of insulation of the motor very easy. Switches are done away with entirely by the use of a choking coil on the secondary motor circuit. When alternate current motors become commercially successful, a method of working of this kind will probably be most useful and practical.

Cupidoscope.—An amusing electrical novelty is brought out by Messrs. J. and C. B. Gibson, 46, Cockburn-street, Edinburgh, for diversion at evening parties and bazaars, and its use will tend at once to break down that initial restraint so often felt at these assemblies. The cupidoscope is a small box containing bell and battery, and a number of lids and pointers. Gentlemen and ladies range themselves in two rows. The first gentleman takes charge of the instrument, and calls upon No. 1 lady to open the lid of the cupidoscope numbered one, and to set the pointer to the number of the gentleman she fancies, afterwards closing the lid, so that her choice is only known to herself, and so on through the whole company. The pushes are then pressed to see who have chosen mutually. After this has been seen, the handle at the end is pressed back, which sets all the pointers to zero ready for use again, so that no choice, unless reciprocated, is known to the company. Hearty amusement will result, and perhaps, even—who knows?—lead to "electric matches."

Patent Decision.—A decision has been given by the Supreme Court of the United States in the case of the Bate Refrigerating Company against Hammond, which is felt to be of considerable importance, but the actual bearing of which seems still to be in considerable doubt. The American patent is granted on condition that it is in force only so long as a foreign patent is in force. The Supreme Court does not, it appears, as, indeed, some papers have made out, overthrow this, but reaffirms it; but in contravention of the opinion of the lower court, it holds that the Canadian patent (which is for five years, but can be extended to fifteen), by reason of its being extended, has never actually expired. This decision will revivify some of the early electrical patents, amongst which are some of Edison's early patents, and, it is thought, strengthen their position; but it is not so sure that other and earlier patents will not also be revivified, and we hear it stated that a patent of Dr Woodward's, of August, 1874, clearly describing a carbon in an exhausted glass receiver, and setting forth, with illustrations, the subdivision in parallel of the incandescent circuit, will remain in force by this decision. The importance of this patent, it is said, has been felt by financiers in America, and very large sums are said to have been offered for the rights of this patent, which may prove to be valuable. We must evidently wait, to see the effect of the decision on the American companies.

Electric Light Buoys.—Atlantic liners have had sometimes to wait for six hours at New York, after straining their utmost for quick passage across, because of the difficulty of entering the channel at night. To facilitate the piloting of steamers, New York Harbour is now lighted by electric light buoys, fitted with incandescent lamps of 100 c.p., which are fed by a current generated on shore and conveyed by cables laid under the sea. The work has been carried out under the direction of Lieut.-Commander Mackenzie and First Lieut. Millis, of the United States Navy, for the Lighthouse Board. The lights are coloured white and red, and mark the deep channel. They are fitted with strong protecting glasses and iron ribs, mounted on the top of long wood spars, 45ft. long, and shackled at the bottom to a cast-iron sinker weighing two tons. The lamps project some distance out of the water. The whole of the top, containing lamp and connections likely to get out of repair, is removable bodily. The cables employed are 32,000ft. of three-conductor cable used as mains, and 15,000ft. of double conductor used at the buoys. The station is situated at Sandy Hook, and is admirably arranged with boilers, engines, and dynamos, all duplicated. Special precautions have been taken to secure good insulation and facility of testing, and altogether the system is well worthy of imitation. Details of the fittings are shown in the *Electrical World* for Feb. 2.

The Submarine Electric Torpedo Ship.—The preparation of the submarine torpedo vessel "Peral," says the Madrid correspondent of the *Daily News*, will be complete on February 20, when the official experiments will be made, including the blowing up of an old wooden corvette in the Bay of Cadiz. Lieutenant Peral is so confident of the success of his invention that he has prepared plans and estimates for building in the Spanish dockyards forty larger submarine torpedo vessels of 130 tons each, at a total cost of twelve millions of pesetas for the whole squadron, and half a million of pesetas for establishing 10 stations on the coasts of Spain and Morocco, where these vessels would get the electrical accumulators replenished. Lieut. Peral says 600 men and 160 officers would be required to man his submarine vessels, which would always be kept ready for war, with electricity stored on board. The crews would be exercised four times each year in torpedo manœuvres. One year would suffice to get the squadron built, and electrical stations fitted up at Barcelona, Mahon, Valencia, Carthagena, Passages, Bilbao, Vigo, Ferrol, Cadiz, and Ceuta, the latter two stations being selected because Lieut. Peral thinks Spanish interests and aspirations require powerful means for action in the Straits of Gibraltar. He declares that the new submarine vessels can be used not only for the defence of the coasts, but might be taken out in tow for offensive purposes by larger war vessels, on condition that the latter carried machinery and means to replenish the reserves of electricity indispensable for navigating and maintaining the fighting powers of the submarine craft.

The British Association.—Since it was decided by the members of the British Association for the Advancement of Science to hold their annual gathering in Newcastle this year, says the *Newcastle Chronicle*, the local secretaries have been most indefatigable in carrying out the necessary arrangements. They have attended to their duties at the offices, in the Literary and Philosophical Institute, most zealously, under the direction of the hon. secretary (Prof. J. H. Merivale). Nothing also will be wanted on the part of leading gentlemen of the dis-

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trict to ensure the great objects in view, a cordial welcome to the distinguished visitors and highly successful and instructive meetings. According to present arrangements, a large number of halls will be engaged. On Wednesday evening, the 11th September, the practical business of the association will begin by the delivery of the president's address. Then from the following day until the 18th the members will devote themselves to the reading of papers and discussions on the same. On the evening following the delivery of the president's address, and also on the 16th, a lecture will be delivered, and on Saturday night a lecture, it is expected, will be given for the benefit of the working classes generally. On one of the evenings a soiree will be held, whilst during the whole of Thursday, the 19th, the members will visit various places of interest in the locality. So favourable was the impression made of the visits to Tyneside in 1838 and 1863 that it is morally certain the visit of the association to Tyneside this year will rank amongst the most successful of the meetings of recent years, and will be as profitable to all concerned as any of its predecessors.

Electrical Coast Communication.—We are glad to hear that an important arrangement is about to be carried out which promises to be of great benefit to fishermen and shipowners. The Plymouth Chamber of Commerce recently suggested to Lloyd's society that it should permit its men at the various signal stations to send two telegraphic reports daily to adjacent ports free of charge. Each of Lloyd's signal stations has at present a private wire connecting it with the Post Office telegraph system, paying a royalty to the Post Office for every message despatched. Lloyd's society, after some correspondence, has generously recognised the importance of the question, and the honorary secretary of the Plymouth Chamber has been officially informed that the society will gratuitously perform the service described provided the Government forego their royalty upon such messages. The reports so sent would be exhibited at some conspicuous place in each port, and the Plymouth Chamber has undertaken to arrange for the gratuitous exhibiting of these reports at the various centres. The Chamber is also in communication with the Government departments on the subject, and it is hoped that within the next few days there will be authority for announcing that the Government are also prepared to do their share of this valuable work in the same generous spirit as that displayed by Lloyd's society. The signal stations belonging to Lloyd's at present occupy 22 of the most prominent positions as headlands and islands along our coast. The free connection of these to the ports is an important advance on the marine economy of the nation, and it is to be hoped that the connecting of the coastguard and lifeboat stations and lighthouses with the telegraph system of the country will very shortly follow.

The Submarine Cables.—The English and French Governments, it is stated by the Central News, have failed to arrive at an agreement respecting the purchase of the Anglo-French cables from the Submarine Telegraph Company. At the time when the British Government decided definitely not to renew the concession to the Submarine Telegraph Company it was understood that the two Governments should purchase the cables of that company at a valuation, and it is alleged that a promise was given by the British Treasury to that effect. The French Government, however, is now objecting to the purchase of these cables upon any terms, on the ground that they are too old for satisfactory working, and that it would be preferable to lay new and better cables. Mr. W. L. Jackson, M.P., of the Treasury, and Mr. Patey, of the General Post Office, went to Paris recently, and had prolonged conferences with M. Coulon, Minister of Posts and Telegraphs, on the subject, but without altering the opinion entertained by that gentleman. Since these conferences in Paris M. Coulon has sent engineers from France to inspect and test the submarine plant and cables in conjunction with the English Post Office engineers. A thorough examination was made at Dover, as well as at East Dean, near Eastbourne, and as a result of these investigations, the Central News learns, reports have been forwarded to Paris which are by no means favourable to the purchase of the submarine cables. It is believed that the British Government will yield to the wishes of France in this matter, and that entirely new cables will be constructed for working between the two countries. It is somewhat significant, too, that although an agreement has been signed by Belgium and England for working the Anglo-Belgium cables, these have not yet been bought, nor has the British Treasury made any offer for them. It is probable that if new cables are laid between England and France, they will also be laid between England and Belgium. This new development of affairs is a hardship upon the Submarine Company, but it is difficult to see how, in face of the determined opposition of France, the cables of that company can be purchased by England.

Electric Census Taker.—Statisticians may be interested to learn that an electric tabulating system has been invented by Mr. Herman Hollerith, of Washington, to sort the returns of the census cards, or other statistics embodying groups of facts or figures. This apparatus is fully described and illustrated in the New York *Electrical Review* of January 26. Relays are used to control the circuits of the receiving boxes of the cards. When, for example, a card punched for "native, white and male," is placed in the press, the corresponding relays are actuated, thus forming a secondary circuit through the magnet native-white-male, thus operating the corresponding counter or sorting box. In this manner any desirable or possible combinations of the data recorded on the cards may be tabulated. For the more complicated combinations special relays, with multiple contact points, are constructed. It will generally be found that a scheme can be arranged which will bring the most complicated tabulation into a comparatively simple mechanical arrangement. If, for example, there are 10 facts, each of which should be tabulated in combination with 10 other facts, there will be 100 combinations which would require that number of counters. However, as this work is entirely mechanical, such checks can readily be arranged as to secure absolute accuracy in the results. In this note reference has only been made to the population statistics of a census and the army health statistics. This method, however, is directly applicable to many other forms of statistical compilations, among which may be mentioned the statistics of registration of births, deaths, and marriages. Dr. John S. Billings, a well known American authority on statistical matters, says: "It is comparatively simple, not liable to get out of order, and does its work rapidly and accurately. I have watched with great interest the progress in developing and perfecting this machine, because seven years ago I became satisfied that some such system was possible and desirable, and advised Mr. Hollerith, who was

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then engaged in census work, to take the matter up and devise such a machine as is needed for counting various combinations of large numbers of data, as in census work or in vital statistics. I think that he has succeeded, and that compilers of demographical data will be glad to know of this system."

Halifax.—A letter was read at the Halifax Town Council from Mr. Holroyd Smith in connection with the Anglo-American Brush Electric Light Corporation. The letter, dated January 28th, was as follows: "Dear Sir,—I beg to confirm the verbal proposal made to you respecting establishing the electric light in Halifax—namely, that if the Corporation would be good enough to accord me their undivided support, I am prepared to apply to Parliament for the necessary orders under the Acts of 1882 and 1888, to purchase or lease the land required for a central station and be at the entire cost of the installation, including buildings, engines, dynamos, instruments, overhead distributing wires, transformers or batteries for the houses and shops, with wires, lamps, etc., and to apply the electricity to users by meter at 8d. per unit (which is equivalent to gas at 4s. per 1,000). In order to secure a sufficient number of users to warrant the large outlay necessary for a successful enterprise, it is further asked that the Corporation light the public buildings, such as the town hall, the library, Bank Field, etc., and should the number of glow lamps exceed 1,000 a special liberal discount would be allowed. Further, that the streets be lighted by arc lamps of, say, 2,000 c.p., to be erected and maintained at a rental of £27 per lamp per annum, the number of lamps to be not less than 25, distributed as the Corporation may think fit. If the Corporation favourably entertain my proposal, and a sufficient number of users undertake to adopt the light, I am in a position to commence operations at once.—I am, yours, respectfully, M. Holroyd Smith." A second letter was read from Mr. Holroyd Smith referring to the contemplated enlargement of the gas works, and asking the Council to defer any project of that kind in order that electric lighting might have a fair trial. A proposal was submitted by Messrs. England and Foster, solicitors, on behalf of the inhabitants, saying that over 60 persons had agreed mutually to put down plant and take the light when provided, and immediately the consent of the Corporation has been obtained, it is intended to form a company, called the Halifax Mutual Electric Light and Power Company, Limited, for the purpose of carrying out the system, and an influential board of directors has been already secured. Arrangements, it was stated, have been made with the Schmidt-Douglas Electric Company, Limited, of London, Manchester, and Bradford, for putting down the necessary plant requisite for supplying the electric current. Permission to take overhead wires over various streets would be asked. Letters were also read, asking the Corporation to countenance their rival projects, from Messrs. Blakey, Emmott, and Co., suggesting a preliminary supply from their works until a central station were completed, and from Mr. J. R. Smith. The Mayor suggested the letters had better be referred to a committee, and the following gentlemen were appointed to deal with them: The Mayor, Aldermen Midgley and Pollard, and Messrs. J. W. Davis, J. Bairstow, J. Binns, J. Oddie, W. Utley, and W. Brear.

Southwark Electric Railway.—Some interesting details of the working of the electric railway for the South of London were given at the meeting of the City of London and Southwark Subway Company, held on Tuesday, at Winchester House, Old Broad-street. Mr. C. Grey Mott presided, and referred with satisfaction to the extremely rapid progress which had been made in the construction of the line and works, and stated that they anticipated that the whole of the line would be completed within six or eight weeks, with the exception of a small portion at the Stockwell end. They had obtained a large piece of land at the Stockwell end, where they proposed to concentrate the whole of the engines required in connection with the working of the line, whether for the traction of the carriages, the hydraulic lifts, the lighting of the stations and carriages, the works in connection with the repairing of the engines and carriages, and the general repairing shops. Since the last meeting they had made a very important contract with Messrs. Mather and Platt, of Manchester, for working the line by electric power. The locomotive expenses connected with the ordinary working of an English railway varied from 7½d. to 1s. a mile, according to the special circumstances of the traffic and the nature of the line. The average cost of working a steam locomotive might thus be taken at 9d. a mile, whereas Messrs. Mather and Platt estimated the locomotive expenses on their subway at 3d. a mile, and they had entered into a guarantee for two years that in no circumstances should the cost exceed 3½d. a mile, or they would themselves pay the whole of the excess. On the other hand, the ordinary railway train would carry an average of, say, 250 passengers, whereas trains on their subway would only seat a little over 100. It would therefore require nearly two and a half of their trains to equal the average capacity of one English steam locomotive train, which, however, ran throughout the greater part of the day not one-quarter filled, there being consequently an enormous dead weight, which was earning no return. On their subway they would have very much less dead weight to move. On the Inner Circle Railway a 10 minute service was run, though other trains entered certain of the stations, and thus made the service a more frequent one than 10 minutes but on the subway it was proposed to run a three minute service. The result of that would be that whereas on the Inner Circle there were six trains an hour, on the subway there would be 20 trains in the same time. They ought, therefore, to obtain a traffic larger, proportionately, than that on the Inner Circle, but if they carried anything like that traffic, he believed they would be able to earn such a dividend as would place their shares at a price which would be satisfactory to all the shareholders. Messrs. Mather and Platt had undertaken that their trains should run at a speed equal to 15 miles an hour, including stoppages, whereas he believed that the speed at which the Inner Circle trains ran was 12 miles an hour, including stoppages. The total time occupied in going from King William-street, City, to Stockwell by the subway would be no more than 12 minutes, and to Kennington Oval no more than 10 minutes. Hitherto, as many of them were aware, the journey to the Oval had been long and tedious. They had also arranged with the firm mentioned for lighting the trains, stations, and works by electricity. He hoped the proprietors would consider, in view of what he had stated, that they had a fair and satisfactory prospect before them; and he trusted when they next met that he would be able to announce that the line was open, or else to name the day on which their trains would start running.

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SOME PECULIARITIES OF ELECTRO-DEPOSITION.

BY ALEXANDER WATT.

In depositing metals from solutions of their salts by electrolysis, the eye of the experimentalist is often attracted to some unusual condition or form of the deposited metal for which at the moment he is unable to account, and which in some cases even further reflection fails to elucidate. Such phenomena, however, scarcely deserve to be passed by without some attempt being made either to account for them, or at least to bring them to the notice of other observers who may have witnessed similar effects under like or other conditions. In calling attention to a few of the many "peculiarities" of electro-deposition which I have met with in my own practice, I do so more for the purpose of recording the facts than with a view (except in one or two instances, probably) to suggest explanations which, for aught I know, may be beyond the reach of any of us. In order that the peculiarities referred to may be considered individually, I purpose describing them under separate headings, giving the name of the electrolyte in each case from which the result was obtained, as also the conditions under which it was electrolytically treated, and I shall be much pleased if any of the readers of this journal who may have met with similar freaks of electro-deposition should feel disposed to offer such explanations as they think may account for them.

Refusal of Bright Metallic Surfaces to Receive the Deposits.—It is a well-known fact that on highly-polished surfaces of metals the electro-deposited metal can seldom be made to adhere with tenacity, but more especially is this the case with cold solutions. It is true that a mere film of gold or silver may be deposited upon polished brass or german silver which will stand the friction of the moist revolving scratch-brush, but a stouter coating would inevitably "strip" or peel off the underlying metal, unless the brightened surface received a previous scouring with pumice-powder and water, or a coating of mercury by dipping the article to be plated in the ordinary mercurial solution used for such purposes. And this disinclination of metals to adhere to bright metallic surfaces is more particularly noticeable, I believe, when we attempt to coat any given metal with the same metal. Indeed, I have before had occasion to express my firm belief that metals do not adhere well to their kind when deposited by electrolysis, and I am even disposed to think that each time an article is removed from a bath for the purpose of examining it, even for an instant, that the subsequent deposit forms a distinct layer upon the previous film, and not a perfect continuation of the original deposit. In the case of nickel this is often noticeable in a marked degree, and I have known a rod of brass, or "stop" suspended from the negative conducting rod of a nickel bath to be coated with innumerable layers of the metal, each of which curled up and separated from its predecessor, although the rod had never been removed from the liquor. In this case there is little doubt that each time the bath was used from day to day, the new deposit which took place upon the rod formed a separate and distinct layer upon the surface of the metal which had been deposited on it the day before. In connection with this latter view, and the disinclination of metals to deposit upon bright metallic surfaces, the following curious result was obtained some time since when pursuing a course of experiments in the electro-deposition of zinc. In these experiments it was desirable to deposit zinc upon thin sheets of the same metal, for which purpose the purest commercial article was procured. In most instances the plates of sheet zinc, before being used as cathodes, were pickled and scoured, so as to present a clean and slightly rough surface; but on one occasion the plates—which presented the usual bright surface of rolled zinc—were not so carefully prepared as I have indicated, the result being that the deposited zinc only partially covered the cathodes of the same metal, while at the same time the film was absolutely non-adherent, and could be stripped off the zinc plates by simply lifting the metal with the point of a penknife, and then gently pulling it away from the bright surface of the zinc cathodes. On examining the deposit before it was removed, it was found to be riddled with holes, through which the bright sheet zinc was quite visible, while a portion of the stripped metal when held up to the light presented a very peculiar retiform appearance, the metal (zinc) being at the same time perfectly reguline, tough, and chemically pure. Adopting the method which I introduced in former papers "On the Electrolysis of Lead and Tin Salts,"* I determined to treat the porous zinc deposit as a *photographic negative*, and to obtain prints or positive proofs from it in the same way as that adopted in the ordinary processes of photographic printing. To accomplish this, a portion of the deposited metal was laid on the glass plate of an ordinary photographic printing frame. A piece of sensitised albuminised paper was then placed over it, then a few folds of blotting paper, and finally the shutter of the frame was fixed in its place. The glass of the frame was then exposed to strong sunlight for at least an hour, after which the picture, a reproduction of which is shown in Fig. 1, was withdrawn, and subsequently washed and toned in a strong solution of hyposulphite of soda, to which a few drops of chloride of platinum† were added. After remaining about 20 minutes in this toning bath, the print was well washed and dried.

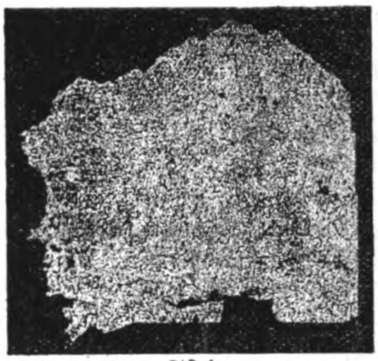

FIG 1

Deposit only on Lower Corners of the Cathode.—When electrolysing a solution of nitrate of lead, consisting of 50 grains of the salt dissolved in 10 ounces of water, with the current of one small Daniell cell, I found that the lower corners of the plate slowly received a deposit of lead, but beyond these limits the metal refused to extend with the current employed. An illustration of the form of the deposit is shown in Fig. 2. When the liquid was diluted, and two cells used, an irregular or patchy film was obtained, the metal only appearing on parts of the cathode, while portions of the deposit were of a non-metallic character.

FIG 2

FIG 3

FIG 4

No Deposit on Lower Corners of the Cathode.—A result of an opposite character to the foregoing was obtained during the electrolysis of a solution of pertartrate of iron—prepared by digesting moist hydrated peroxide of iron in a boiling solution of tartaric acid, the liquid being afterwards diluted. With the current from four Daniells in series no deposit was obtained while the cathode remained stationary, but when it was briskly moved about in the bath deposition of iron gradually took place on all parts of the immersed surface of the cathode except at the lower corners, where there was no deposit, while the upper portion of the deposited metal assumed an irregular or jagged appearance, due to the negative plate having been kept in motion. An illustration of this result is shown in Fig. 3, in which the white surfaces at the lower corners of the plate indicate where the metal was not deposited.

Deposit Commences from the Edges of the Cathode.—When a very weak solution of acetate of lead—50 grains of the salt

* *Electrical Review*.

† Toning with platinum was first suggested by the writer in the *Photographic News*, July, 1859.

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dissolved in 10 ounces of water and slightly acidified with acetic acid—was electrolysed with the current from two Daniells in series, a deposit of lead at first slowly formed on one edge only of the cathode, but after a short time a corresponding film formed on the opposite edge of the plate, as in Fig. 4, the two films gradually and very slowly extending towards the centre of the cathode, while no deposit whatever occurred either upon the upper or lower surfaces of the plate. After the cathode had been in the bath about 15 minutes from the commencement of the experiment, minute crystals began to form on the surface of the films referred to, from which point the lateral extension of the films appeared to cease, the plate somewhat assuming the appearance shown in Fig. 5. A very similar result was obtained when a solution of basic nitrite of lead was electrolysed with the current from a single Daniell cell.

Deposit only on Upper Part of the Cathode.—On electrolysing a solution of sulphocyanide of lead (prepared by digesting moist carbonate of lead in a hot and strong solution of sulphocyanide of potassium, the solution being afterwards cooled and diluted) with the current from one small Daniell, a deposit of lead slowly formed on the upper part of the cathode—a brass plate—but even after a long immersion no further deposit was obtained. The form of this deposit is shown in Fig. 6. I may state that I have frequently obtained metallic films of this character when electrolysing weak solutions (benzoate of peroxide of iron, for example) with a feeble current. When three cells in series were employed with the preceding solution, the cathode became at once coated all over.

Crescent-shaped Deposits.—Results of this character, as in the foregoing case, usually occur with solutions poor in metal, when worked with a feeble current. I have also

FIG 5

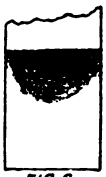

FIG 6

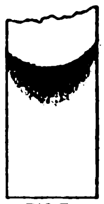

FIG 7

obtained similar results when endeavouring to reduce aluminium from solutions of its salts, both with weak and very strong currents; but in these cases it was not aluminium, but traces of iron and other foreign metals with which the aluminium salts were impregnated, that became reduced by the current. When treating aluminium salts, but more especially *acid* salts, with currents of varying density, I have very frequently found a deposit to take place only at the upper surface of the cathode—not as shown in Fig. 6, but of a crescent form, as illustrated in the accompanying engraving (Fig. 7). These deposits, however, were, as I have stated, due to metallic impurities contained in the aluminium salts used, and were in no degree due to the aluminium itself. In some instances the same form of deposit will take place whether the cathode is allowed to remain stationary or is briskly agitated in the bath, but more generally under the latter condition.

Deposit only on Lower Part of Cathode.—When electrolysing a weak solution of persulphate of iron (prepared by adding three fluid drachms of the concentrated solution to about 10 ounces of water) with the current from three Daniells, I found that the deposit, which commenced at the bottom and lower edges of the cathode, slowly proceeded upward for a short time, after which no further deposit could be obtained upon the upper surface of the negative plate. An example of this is shown in Fig. 8. I may state that many results of a similar character and form have been obtained from other iron salts, and also from solutions of other metals. In the illustration it will be noticed that the upper portion of the film forms an arch-like curve.

Upper Portion of Deposit an Inverted Arch.—In the foregoing example, we have noticed that the upper part of the deposit was curved like an arch; in the illustration Fig. 9, the curve is in precisely the opposite direction, forming, as it were, an inverted arch. This result was obtained during the electrolysis of a very weak solution, composed of persulphate of iron and sulphate of soda, with the current from three small Daniells. In this case the deposit started at the bottom of the cathode, gradually spreading upward, when the film assumed the form indicated in the woodcut, no deposit whatever taking place beyond the outline shown.

Deposit only on Back of the Cathode.—When electrolysing a solution of potassio-tartrate of cobalt with the current from two Daniell cells, a very slight trace only of metal appeared on the surface of the cathode—a brass plate—facing the positive electrode. On examining the back of the plate, however, I was surprised to find that it was coated all over with cobalt. Thinking that possibly I had

FIG 8

FIG 9

FIG 10

inadvertently turned the plate when first examining it, I repeated the experiment with a newly-prepared plate, when I found that a precisely similar result was obtained, namely, that the metal deposited uniformly on the surface of the cathode farthest from the anode—that is, the back of the plate—while the front of the plate had scarcely a trace of metal upon it. The same experiment was repeated two days after with exactly the same result.

Partial Metallic Deposit on Lower Part of Plate only.—A solution of sulphocyanide of cobalt was electrolysed with the current from three Daniells, and a deposit of cobalt slowly formed on the lower edges of the plate to the extent of about half an inch, when a dark brown non-metallic film was deposited in continuation of the metallic film, this having a graduated depth of colour, the darkest portion being nearest the upper part of the plate.

Zigzag Deposits of Copper.—A solution of borate of copper in acetic acid was diluted and electrolysed with the current from a single Daniell. A steel plate was used as a cathode, and this was kept briskly in motion in the bath for about a minute. When withdrawn from the solution, it was found that the deposited metal assumed a very peculiar zigzag form as represented in Fig. 10, while the deposit on the back of the plate, the form of which is shown in Fig. 11, presented a very similar character. The deposited copper was dull, with the exception of a narrow band beyond the margin of the film, which was exceedingly bright. This latter fringe of the deposit is shown by the white outlines beyond the darker shading of the illustrations. The dotted lines above the white outlines referred to show where a slight film of copper appeared at the spots indicated.

FIG 11

FIG 12

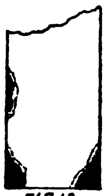

FIG 13

Deposit of a Horseshoe Form.—This peculiar result was obtained under the following conditions: A portion of the foregoing solution was again diluted with water with a view to ascertain whether any further freaks of deposition would present themselves. A clean steel plate was then immersed in the bath, the same current being used, and kept gently in motion. On removing the plate the deposit was now found to have assumed the form shown in the accompanying illustration (Fig. 12), from which it will be seen that the deposit, which was thicker at those parts indicated by the darker shading of the woodcut, assumed a form somewhat resembling a horseshoe, while the remaining portions of the plate were entirely free from any deposit whatever. It was next determined to see if a stronger current would make any, and what, diffe-

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rence in the form of the deposit, for which purpose two Daniells in series were used, when the succeeding deposit was observed to take place in detached patches, as indicated in Fig. 13, the same character of film being discovered on both sides of the plate. It should be mentioned that the latter result was obtained when the cathode was allowed to remain stationary in the bath for about a minute. As in the preceding results, the patches of deposited metal were fringed with a perfectly bright band of copper, the remainder of the deposit being comparatively dull.

In conclusion, I may state that besides the peculiarities of electro-deposition to which I have had the pleasure to call attention, I have observed many others, which may possibly form the subject of a future paper.

ELECTRIC LOCOMOTIVE FOR MINES.

The application of electricity as a motive power in mines is not a new departure. Some years ago Messrs. Siemens and Halske constructed an electric locomotive for the Zankerode mine, the current being supplied by conductors supported from the roof of the gallery, and other installations on the conductor system soon followed. Mr. Reckenzaun was, we believe, the first to use storage batteries as the source of power, and a locomotive designed by him for the Trafalgar Colliery has been described and illustrated in our issue of June 25, 1886. The latest example of electric haulage in mines is also a locomotive carrying its own store of power in the shape of accumulators, and this has been briefly referred to in our review of last year's progress in electrical engineering. By the courtesy of Messrs. Immisch and Co., the makers, we are now in a position to place some details of this locomotive before our readers. It was built for the Wharncliffe Silkstone Colliery to run on a 1ft. 9in. gauge, and in a drift 4ft. high by 4ft. 6in. wide, whilst its total weight in working order was not to exceed $2\frac{1}{2}$ tons. Before entering upon a description of this locomotive, we may give the results of some trials which were made with it on a surface line at the colliery by Mr. E. B. Walker, and communicated to the Midland Institute of Mining, Civil, and Mechanical Engineers in December last. The line contained a short piece of level; 200 yards of 1 in 70; 150 yards of 1 in 40; 250 yards of 1 in 25; and 200 yards of 1 in 40. On the gradient of 1 in 70 the locomotive would just move a train of twenty loaded corves, weighing together 11 tons, and with fifteen corves, representing $8\frac{1}{2}$ tons, a speed of three miles an hour was obtained, the current being 45 amperes at 100 volts pressure. On the gradient of 1 in 40 the maximum load was eight corves, and on 1 in 25 it was six corves, the speed being a little over two miles an hour. On the level the locomotive could draw thirty corves, the current being 45 amperes.

The frame of the locomotive is supported on springs on axle-boxes outside the wheels, and in order to secure a maximum degree of steadiness, four sets of storage cells have been suspended in front and rear of the wheels from the platform. The wheels are coupled by rods to fully utilise the weight for adhesion. We give herewith a plan and elevation of this locomotive.

The storage battery consists of forty-four modified Tatham cells, each box being 10in. by $6\frac{1}{2}$in. by 11in. high. The boxes are lead lined, and arranged in sections of three in wooden trays. Each box contains nineteen plates, 7in. by $4\frac{1}{4}$in. by $\frac{7}{32}$in. thick, and has a capacity of 150 ampere-hours, the weight being 53lb. The rate of discharge varies between 25 and 50 amperes, and at starting rises occasionally to 65 amperes. Taking 40 amperes as the average rate, the weight of these cells per horse-power works out to nearly 500lb.; and per horse-power hour storage capacity to 134lb. We are informed by Messrs. Immisch that they are now engaged in working out several improvements by which the storage capacity, as compared to weight, will be increased. The motor, which is placed underneath the platform and between the wheels, is of the ordinary Immisch type. The armature is 10in. diameter, and wound with No. 12 S.W.G. wire. There are 480 wires counted around the periphery, and the commutator has 48 sections. The resistance of the armature is ·23 ohm. The field is of the double horseshoe type, and wound with No. 9 S.W.G. wire in two parallels, there being 560 effective turns. The resistance is ·14 ohm, or total resistance of the motor ·37 ohm. The normal current is 45 amperes, and the speed 1,000 revolutions per minute, with a terminal pressure of 100 volts. The weight of the motor is 4cwt., and it gives 4 h.p. at 800 revolutions per minute. On the armature

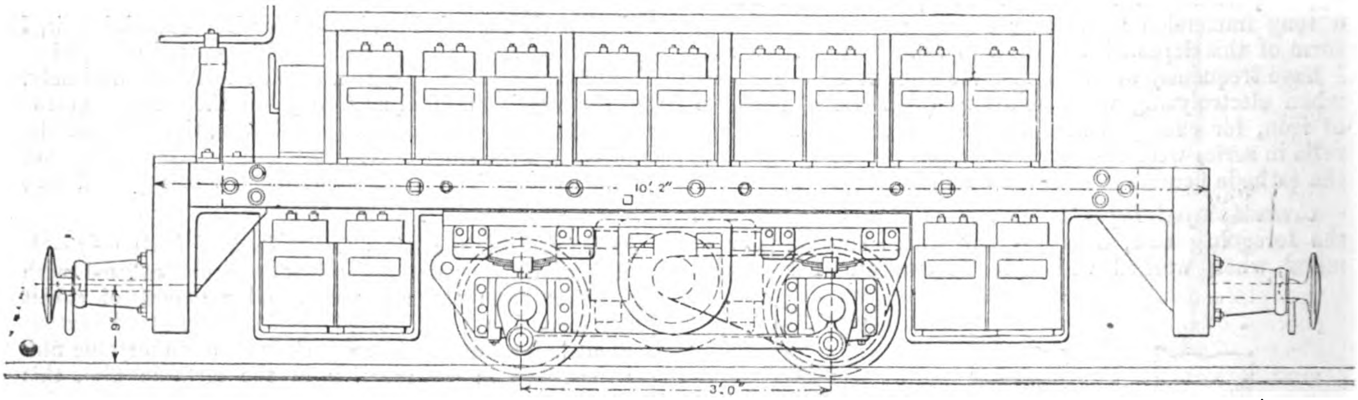

Fig. 1

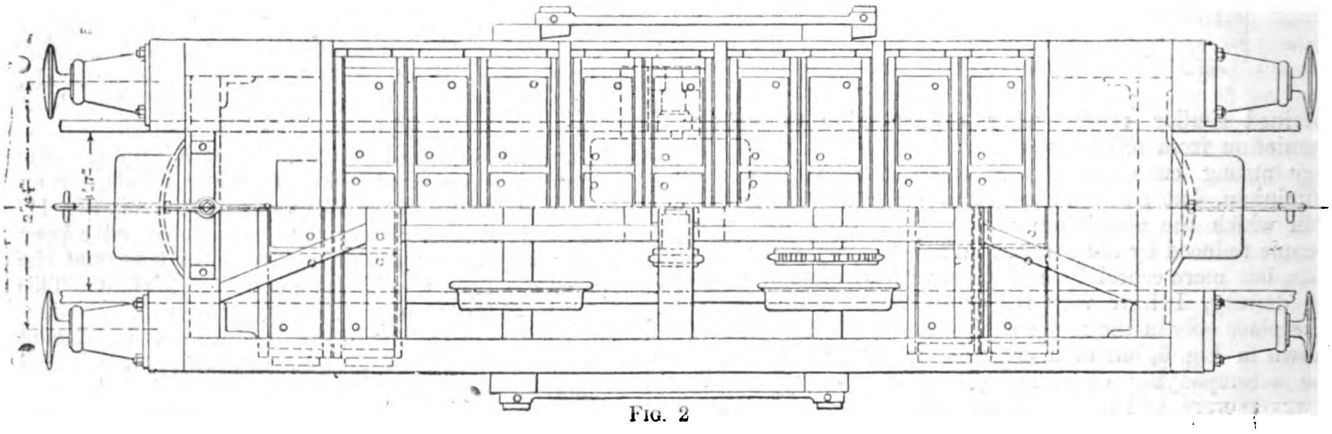

Fig. 2

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spindle is a small phosphor-bronze pinion; this gears into four steel pinions, placed in the same plane, and 90deg. distant from each other. These pinions are bushed with gunmetal, and run on steel pins carried on a cast-iron disc. The disc revolves on a journal turned outside of the end of the motor bearing. Outside of, but in the same plane as these pinions, is fixed an annular casting of gunmetal, with teeth cut on the inside. The steel pinions gear into the ring, which forms a fulcrum on which they revolve when the motor spindle turns. The power is transmitted from the cast-iron disc by a sprocket pinion keyed to it on the inside next the motor, and a steel chain connects this sprocket pinion to a suitable wheel mounted on one of the axles, whilst the other axle is connected with this by the coupling rods already mentioned. The direction of motion is reversed by a switch, which reverses the magnetisation of the field, and the speed is regulated by iron resistance coils. A brake is also provided. The current for charging the battery is furnished by an Immisch dynamo, which is driven by belt from a Willans engine.—*Industries.*

SUGGESTIONS FOR ELECTRIC TRACTION.

At the meeting of the Ohio State Tramway Association (as reported by the *Street Railway Journal*), a paper was read by Mr. A. G. Clark, not as an electrical expert, but as a layman, giving practical suggestions from his own experience, extending from the establishment of the Baltimore road in 1884. After testifying to his belief in overhead rather than underground systems, as the only ones practically successful on a large scale in America, Mr. Clark continues: In the first place, do not try cheap and inadequate construction; there is no place where economy can be so misapplied, for electrical machinery cheaply and poorly constructed is a most constant source of annoyance and expense. Second, start out with the knowledge that you will duplicate every part of your construction, both steam and electrical, as the most perfect of mechanism may fail, and nothing is more annoying to the travelling public than delay; in addition to this you are repaid in the economy of operation and the saving of your machinery, as the non-crowding of boilers saves coal and the changing off of machinery gives it a rest, which is most desirable, especially to the electrical part, giving it a chance to cool, and saving many a burn out. Third, cleanliness is essential to satisfactory operation; the motor drivers should be required to keep their motors free from oil and dust, and everything that tends to this end should be provided for them. A pit should be conveniently located so that frequent inspection may be made of the gearing. All electric roads should have extra cars, not only in case of accident, but that in rotation the motors may be inspected and taken apart and cleaned of oil and of any copper dust from the wearing of the brushes. The leaning of electric railroad constructors seem to be all towards placing the motors under the cars and making connection by cog-wheels to the axles; in view of this I have some hesitation in saying that my preference, except in case of heavy grades, is to have the motor in front part of car, for the following reasons: First, it gives a better opportunity for the men to keep them clean. Second, being always in sight, any tendency towards electrical difficulty can be checked at once, thereby often saving an armature. Third, my experience has been that the motor drivers become attached to their special motors like a locomotive engineer does to his engine, and take pride in keeping them in order. Fourth, the motor is out of the way of all chance of getting wet or dirty, or magnetically attracting nails or iron material in the streets. Where there are any considerable grades, the more direct method of connection I should consider of advantage. If very heavy grades are to be overcome, a special tow-car would be of benefit rather than have the heavy and expensive equipment on each car to simply meet the requirements of certain grades. Before beginning to build a power-house great study should be given to the planning of the machinery in the building, for if this is done properly a large saving can be made in expense of working. I believe an observance of the points I have so crudely made—as they are regarded or not—will tend very decidedly to make or mar the success of an electric road.

CORRESPONDENCE.

DOES INVENTING PAY?

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Mr. S. F. Walker's letter on this subject is extremely interesting, but does not, to my thinking, give an entirely correct view of the matter.

Your correspondent is undoubtedly right in his view of the great difficulties which beset the path of him who wishes to devise and put into the market any apparatus or method which is to displace existing ones. Not only is it difficult to produce something that shall be really good and new, but the inventor has also to reckon with the fact that he wants to displace that which represents an investment already made in favour of that which calls for fresh expenditure.

Nevertheless I think Mr. Walker goes too far in advising inventors "to don't." The difficulty, to my thinking, is rather that the majority of inventors go outside their own branch.

As a patent agent, I have frequent opportunity to marvel why cabinet-makers will invent pumps, and bootmakers organs, whilst electricians will put all their energies into chemistry, and so on. It is but natural that then things are put forth that have been tried and abandoned dozens of times. If, however, a man keeps to that which is his daily occupation, he knows the actual working conditions, knows of his own knowledge what is feasible, and will, moreover, more readily find credence when negotiating with capitalists.

This brings me to another matter. Inventors frequently ask their patent agent to find them a purchaser. If the attempt is made, the inventor has as often, woefully often, an entirely Quixotic idea of the commercial value of his improvement. He fails to take into consideration the risks to be run by the capitalist, and asks for terms that must appear ridiculous to any cool-headed man.

If therefore I may advise those who are ingenious enough to make inventions I would say to them:

1. Avoid going outside your own branch.
2. Do not spend more, either in time or in money, upon inventing than you can spare for a luxury. Stick to your regular business, and let inventing not become more than a recreation out of which possibly some good may come.
3. Don't be greedy when you have hit upon something good.—Yours, etc.,

BERNHARD DUKES, Patent Agent

226, High Holborn, London, February 9, 1889.

THE DISCUSSION ON ELECTRIC METERS AT THE SOCIETY OF ARTS.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Mr. Crompton is reported to have said in this discussion that our meter has been working at Liverpool "for some weeks." While thanking Mr. Crompton for calling attention to our instruments, we should be glad to be allowed to state that they have been in use there for about a year, and now number about a hundred, and that the engineers, Messrs. Holmes and Vaudrey, are still ordering them from us.—Yours, etc.,

CHAMBERLAIN AND HOOKHAM, LIMITED.

4, New Bartholomew-street, Birmingham.

The Leber Incandescent Lamp.—Efforts are being made among capitalists of Philadelphia to form a company to push the Leber combination incandescent lamp. This lamp, by an arrangement of carbons and switches, is made to emit light at various candle-powers. The 8-16-32 c.p. lamp is the favourite at present.

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NOTICE.

During the course of the past year we issued steel engraved portraits of Mr. E. Graves, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. Wollaston, M.D., F.R.S., *and* Sir Humphry Davy, F.R.S. *The portraits of* Prof. D. E. Hughes, F.R.S., *and of* Dr. J. Hopkinson, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

ELECTRICAL PROGRESS.

Major Flood Page has done well to direct the attention of readers of the *Times* to the progress of the electrical industries in a letter which we reprint elsewhere. No doubt those who are intimately acquainted with the inner working of an industry are too often occupied with trade concerns to take a general view of the subject. Hence there is no harm in periodically taking them out of the strife and placing them upon an external Mount Pisgah, from whence, as outsiders, they can calmly view the promised land. Their daily routine consists principally in fighting against keen competitors to get orders; they know what orders they have obtained and what they have lost, but these do not make up the industry. No single firm has a chance to estimate for every piece of work, and so the compendious view comes, as we say, from external rather than internal sources. Major Flood Page happens to be in a better position than most people to estimate the progress of electric lighting, so far indeed as it applies to incandescent lighting, for he stands, as it were, in the principal centre for the supply of incandescent lamps, and this supply is a good criterion of progress made. The comparisons he makes relating to the early years of gas and electricity afford curious matter for consideration, and will probably come somewhat in the shape of a surprise to most people. That it should have taken forty years for the gas industry to employ £6,602,010, while the existing electrical companies, inaugurated in about one-tenth of that time, have a capital of over £4,000,000, shows that, owing to the better general education of the people, it now takes less time and trouble to overcome the inertia of conservatism and indisposition to change than it did when gas was introduced. We take it that it is this better education that induces men to come to a conclusion and action sooner than otherwise would be the case. Although men put "cost" in the forefront of the battle, depend upon it they do not forget the incidental advantages which electric lighting, traction, and transmission of power bring in their train. It is a matter of business to growl at a penny and howl at a sixpence, but the blessing of a purer atmosphere, less risk from fire or from explosion, less destruction to decoration, to articles of vertu, is fully appreciated. In assisting to the conclusion to support the industry, as Major Flood Page assures us the world has done, the technical Press may claim a high position. No doubt errors have been committed, but seldom wilfully. Ignorance and inexperience, when put into a position to do evil, have been incontinently handled and corrected before their misdeeds could do much harm, and on the whole the world has been well advised by those whose duty it is to give unbiassed advice. We may deplore that in England we have no such farseeing,

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energetic capitalists as Westinghouse, but it must never for a moment be forgotten that England does not present so good a field for the work as America. If the electric lighting field had been as good, we fancy the capitalist would have been forthcoming. Still, we are surprised that no English capitalist or syndicate has grasped the possibilities of "power supply." Look at that how you may, estimate upon what figures you please, the promised return is far and away greater than for the distribution of light. True, power stations are not required so universally as light stations, but in the teeming centres of manufacturing populations there is every inducement to install such centres, and every prospect of satisfactory results.

There is one phase of the question touched by Major Flood Page that demands remark. Gas pays good dividends, will electricity prove as bountiful? The time for continued big dividends is past. There are still speculations by which fortunes can rapidly be made, or as rapidly lost. The electrical industry is not one of them. That it should pay fairly well is certain, and if it does not, the fault is to be found among the wirepullers and City men, not from anything arising in the industry itself. If, in the early days, company-mongers loaded companies with capital producing no revenue, that is the fault of the company-mongers—not the business. The latter may satisfactorily employ a capital of £100, and give for it a good return; while if the capital be nominally £1,000, of which £900 has gone into the pockets of promoters, the return cannot be proportionate to the capital. There is a damning indictment some day to be written against the promoters of electrical companies, and it is to their insatiable greed that many companies have failed altogether, and others are still in the non-dividend paying stage. A company starting with a fair capital, using the whole of it productively, should not only command a good business, but should pay a good dividend.

The *Times* leader writer ought to recollect a rather vulgar tale about a servant girl, her baby, and her mistress. Her fault ought to be condoned because "it was such a little one"—not the fault, but the baby. The *Times* says, "But London is great, and central stations are frequently small." Just so, but, like the baby, they have generally the inherent power of growing larger. Small beginnings must not be despised, even when they consist of central stations. If it were our purpose to put the *Times* right upon scientific questions, there are several in its leader that would call for animadversion. One statement must, however, be corrected, that "a current representing a hundred horse-power will run along a copper rod without giving a sign of its presence." Electricians would really be in a fix if such were the case, but, as we all know, there are plenty of signs of a current. Perhaps the *Times* means that the copper rod presents no change to the uneducated eye or hand; still, a paper of its pretensions should take pains to be correct or leave the subject alone. It is comforting to find such powerful advocates coming more and more into line with those who have for years insisted upon the advisability of constructing a system of subways throughout the main streets of populous towns. A debateable point is raised with regard to overhead wires and stress of weather. The policy we have advocated is for pioneer overhead wires to remain, say, for three years. The danger from stress of weather, such as snowstorms, etc., is less when the wires are newly run than after the course of years, when fastenings have had time to loosen or chafe, when wires have become unused, unowned, and unexamined. If the telephone, telegraph and electric light companies were compelled to take down all unused wires, there would be less chance of trouble.

This brief glance over general questions will show that the enthusiasm of Major Page as concerning the present and the future prospects of the electrical industry is warranted, though there must be no relaxation of effort to push forward at every point where vested interests can be assailed with the hope of success.

THE BATE REFRIGERATING CASE.

BY GEORGE P. BARTON.

On January 21st the United States Supreme Court rendered its decision in the suit of the Bate Refrigerating Company against George H. Hammond and Co. The issues were specially made up for the purpose of obtaining an expression from the court as to the right construction of the statute relating to the limitation of the terms of the United States patents to the terms of prior foreign patents. This section of the statute is as follows:

"Section 4887. No person shall be debarred from receiving a patent for his invention or discovery, nor shall any patent be declared invalid, by reason of its having been first patented or caused to be patented in a foreign country, unless the same has been introduced into public use in the United States for more than two years prior to the application. But every patent granted for an invention which has been previously patented in a foreign country shall be so limited as to expire at the same time with the foreign patent, or, if there be more than one, at the same time with the one having the shortest term, and in no case shall it be in force more than 17 years."

The decision of the Circuit courts have been that an invention secured in this country by a patent issued after a foreign patent for the same invention becomes public property at the end of the original term of the foreign patent, even though the term of the foreign patent had been extended so as to keep the foreign patent in force, and notwithstanding the application for the United States patent was filed first.

The legal questions involved were considered of such importance to various electric light companies that they were represented by counsel. It was contended on behalf of the Refrigerating Company:

"First. That the words 'first patented or caused to be patented in a foreign country," do not mean 'first patented, or caused to be patented,' before the issuing, or granting, or date of the United States patent, but mean 'first patented, or caused to be patented,' before the date of the application for the United States patent.

"Second. That the declaration of the section, that 'every patent granted for an invention which has been

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previously patented in a foreign country, shall be so limited as to expire at the same time with the foreign patent, or, if there be more than one at the same time, with the one having the shortest term,' does not mean that the patent so granted shall expire at the same time with the term to which the foreign patent was, in fact, limited at the time the United States patent was granted; but it means that it shall expire when the foreign patent expires, without reference to the limitation of the term of such foreign patent in actual force at the time the United States patent was granted."

The court, by Justice Blatchford, sustained this second proposition, finding it unnecessary to consider the first.

The court, after reviewing various decisions of the Circuit Court, holding the contrary of this proposition, says:

"We are of the opinion that, in the present case, where the Canadian statute, under which the extensions of the Canadian patent were granted, was in force when the United States patent was issued, and also when that patent was applied for, and where, by the Canadian statute, the extension of the patent for Canada was a matter entirely of right, at the option of the patentee, on his payment of a required fee, and where the 15 years' term of the Canadian patent has been continuous and without interruption, the United States patent does not expire before the end of the 15 years' duration of the Canadian patent."

The precise point decided, then, is that prior foreign patents as Canadian, Austro-Hungarian, or Italian short term patents, as for five years, or one year, with right to extensions on payment of taxes, or annuities, will not make void United States patents as long as the prior foreign patents are actually kept in force. This decision, then, is important only in those cases where the prior foreign patents have been actually extended and inferentially in cases where the United States patentee had the right to obtain such extensions in the foreign country.

In the important suit of the Edison Electric Light Company against the United States Electric Lighting Company, decided by Judge Wallace last spring, it was held that Edison's patent No. 263,140, dated August 22, 1882, filed August 9, 1880, was void on account of the Austro-Hungarian patent for the same invention, granted July 21, 1881. It appears, however, that the Austro-Hungarian patent was only kept in force until July 21, 1883. The principal question involved in this Edison suit was thus the first proposition, which the Supreme Court has left untouched.

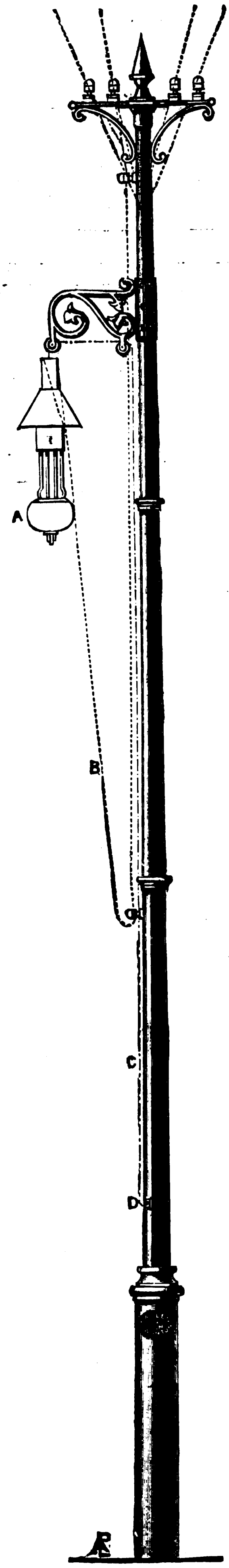
The decision, however, is a victory for the Edison Company in those cases where they have kept their foreign patents alive.

Justice Blatchford, in 1889, speaking for the Supreme Court, reverses Judge Blatchford sitting as circuit judge in 1879, he having held in Reissner *v.* Sharp (16 Blatchford, 383) that the patent involved expired with the first five-year term of the Canadian patent, although the Canadian patent had been extended, and was in force at the time he gave his decision. It will be seen, however, that the most interesting of the two questions presented is still left open.

Justice Blatchford, in the case of Gramme Electrical Company *v.* Arnoux and Hochhausen Electric Company, decided in 1883, held that the date of the filing the application for the United States patent does not in any way relieve the patentee of the statutory limitation, and this is thought to be the correct opinion. The final determination, however, must be left for the Supreme Court, when the precise point raised by the first proposition shall be brought before it.—*Western Electrician.*

STANDARDS FOR ARC LAMPS.

We gave in a recent issue the results of tenders for the standards for the arc lamps to be used in the street lighting at Bath. We now illustrate one of the standards. It will perhaps, however, be convenient to recapitulate the information and the prices quoted for the contract. Tenders were required for about 340 iron electric light standards, 30ft. above ground, with roots varying in depth 3ft., 4ft., 5ft., and 6ft., respectively, with independent flanges, projecting 2ft., to be fixed with wrought



wedges, and delivered free in Bath. The accepted tender was that of Messrs. C. Allen and Son, of Taunton, who quoted £6. 10s. against Messrs. G. Smith and Co., Glas

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gow, £7. 7s. 6d.; Messrs. Buller Jobson, Dudley, £7. 10s.; Messrs. M. and W. Graybrook, Dudley, £8; Messrs. Easton and Waldegrave, Taunton, £8. 2s. 6d.; Messrs. Jukes, Coulson, Stokes, and Co., London, £8. 2s. 6d.; Messrs. Statter and Co., West Drayton, £12. 7s.

It will be seen that the use of these standards involves overhead wires. The design almost explains itself. There is an independent bracket projecting from the post to allow of the lamp being raised and lowered. The lamps are so suspended, A, that they project about 2ft. from the standards towards the street, and they can be let down to the ground for trimming and hoisted into position. When in position they are locked at the point D. B is the conducting wire, and C the flexible rope for lowering the lamp. Of course, the only objection to this form of standard is to be found in the shadows cast. Otherwise it is simple, elegant, and cheap.

ELECTRICAL PIANO MUSIC RECORDER.

In the *Transactions* of the American Institute of Electrical Engineers for January is a description of an electrical apparatus, invented by Mr. Abdank, for the registration and reproduction of the notes of a piano. An apparatus of this kind should be exceedingly useful to composers for reproducing their improvisations, and enquiries have often been made as to the possibility of such an instrument. Mr. Abdank's apparatus comprises two parts—a melograph for recording what is played, and a melotrope for reproducing this music from the record made by the melograph. The melograph consists of a system of contacts fastened under the keyboard; these are connected to an instrument like a Morse recorder, and when the key of the piano is depressed a mark is made on a strip of paper corresponding in position to the note. It not only records the notes by the length of the line, but records the time the note is held. This record, when the piece is finished, is passed through a perforator which perforates a piece of stiff paper with rectangular perforations corresponding to these lines of the record. This is done by means of an electric apparatus which consists of a little square punch, which travels up and down very rapidly, driven by an electric motor. The lines on the paper are first run over with a puncturing pin, then this paper is passed over a series of contacts. Wherever the paper is punctured, connection will be made, which connection will work this little punch at a place corresponding exactly to the place of the line on the record. In other words, this record on stiff paper is an exact counterpart of the other, only that it is perforated with smooth rectangular holes, whereas this is originally merely a written record. This record is then ready for the melotrope—the reproducing apparatus. The melotrope is merely mechanical in its action; but the idea of the inventor was to imitate as nearly as possible the motion of the finger.

In ordinary mechanical piano players, the keys are merely depressed by a force which is constant, and, in short, the whole apparatus is very mechanical in its action; but in this case the inventor has tried to imitate the motion of the finger; in other words, he has tried to depress the keys softly, gently, or with considerable force, to hold them down a longer or shorter time. This is accomplished in the apparatus Mr. Abdank exhibited, by means of a long roller which extends over the length of the keyboard to be played upon. This roller has cut into it a number of grooves, the sides of which are slightly inclined. The instrument exhibited was arranged for three octaves, with 37 notes. There are, therefore, 37 of these grooves. A roller is turned constantly in one direction, and when a string is tightened it pulls down a finger resting on the keys. The tightening of this string is performed by mechanism, consisting of a little wedge which is run into the groove. The little wedge is actuated by levers which run over the paper. Wherever they come opposite to a hole the lever passes through the hole, and in passing through the hole the end of the lever makes a motion which is transmitted to the little wedge. The wedge is pressed into the groove, tightens the spring, and pulls down the hammer, so that wherever there is a hole in the record the corresponding wedge will be pushed into the corresponding groove, which will tighten the string and press down the key, and will hold the key down as long as there is the hole in this paper. The pressure exercised by the finger in playing the piano is sometimes as much as 5lb., so that these little fingers must come down at least with a force of 5lb., and in the melotrope they can come down with even greater force, and the apparatus can play even louder than a person can play. It may be added that the apparatus does not automatically produce *piano* and *fortissimo* effects. Wherever *piano* should be played, and wherever *fortissimo* should be played, it is written on the music, and the effects of *piano* and *fortissimo* are produced by a little lever on the side of the instrument. This little lever does nothing more than run these wedges toward the roller or from it. The force is greater when they are moved towards the roller, and less when they are pulled away. The apparatus can be as well constructed for seven octaves as for three. It is necessary to go over the record by hand and puncture the holes, as the notes not necessary can be left out. Mr. Abdank played the overture to "Carmen" and the "Boulanger March," and afterwards amused his audience by reversing the card and playing it the other way up, which had the effect of giving the chords perfect, but in the minor. Mr. Abdank then played the piece backwards, and also played a piece improvised for the melotrope in his laboratory, and converted it in one hour after he had played it.

VELOCITY OF LIGHT.*

BY SIR WILLIAM THOMSON.

The number of electrostatic units of potential in the electromagnetic unit of potential is essentially a velocity, and experiments have proved it to be so nearly equal to the velocity of light, that from all the direct observations hitherto made we cannot tell whether it is a little greater than, or a little less than, or absolutely equal to, the velocity of light.

Sir W. Thomson is engaged now in making a set of electrometers which will measure by electrostatic force potentials of from 40 volts to 50,000 volts. The standardisation of these instruments, up to 200 or 300 volts, is made exceedingly easy, by aid of his centiampere balance, with a voltaic battery of any kind, primary or secondary, capable of giving a fairly steady current of one-tenth of an ampere through it, and platinoid resistances in series with it. The accuracy of the electromagnetic standardisation, within the range of the direct application of this method, is quite within one-twentieth per cent. A method of multiplication by aid of condensers, which was explained, gives an accuracy quite within one-fifth per cent. for the measurement in volts up to 2,000 or 3,000 volts, and with not much less accuracy, by aid of an intermediary electrometer, up to 10,000 volts. Such a potential as 10,000 volts is convenient for measurement by an electrostatic balance, which was fully explained in the lecture and illustrated by a drawing. But hitherto he has not been able to make sure of the absolute accuracy of this electrostatic balance to closer than one-half per cent. The results of a great number of measurements made in the Physical Laboratory of the University of Glasgow, during the last two months, give the required number, commonly called "v," within one-half per cent. of 300,000 kilometres per second; the velocity of light is known to be within one-fourth per cent. of 300,000 kilometres per second. Results of previous observers for determining "v" had almost absolutely proved for "v" at least as close an agreement with the 300,000 as this. He expressed his obligation to his assistants and students in the Physical Laboratory of Glasgow University, Messrs. Meikle, Shields, Sutherland, and Carver, who worked with the greatest perseverance and accuracy in the laborious and often irksome observations by which he had attempted to determine "v" by the direct electro-

* Abstract of part of lecture at Royal Institution, February 8.

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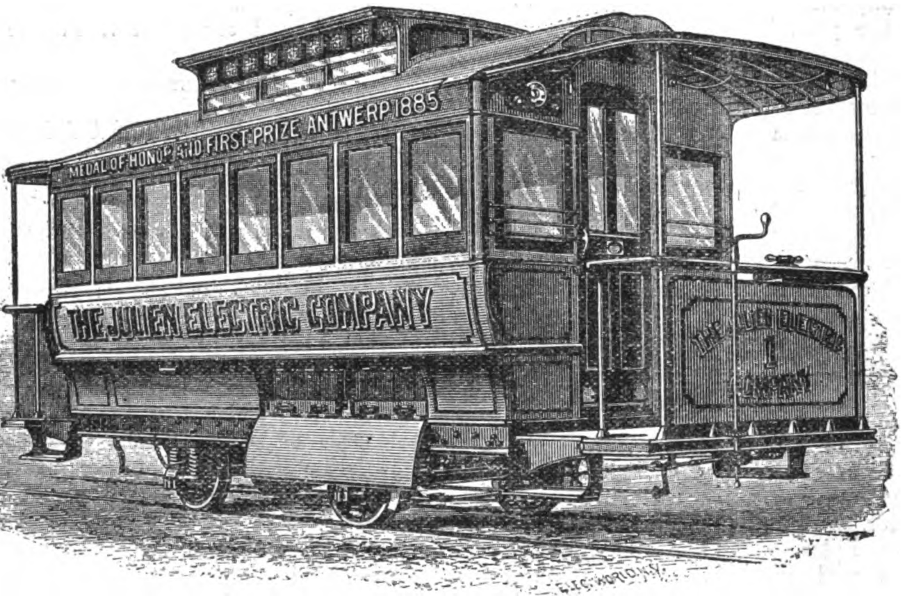
meter method as exactly as, or more exactly than, it has been determined by other observers and other methods.

THE JULIEN TRACTION SYSTEM.

It will be remembered that successful experiments have been recently made in Birmingham under the auspices of Messrs. Elwell-Parker, as constructors of tramcars driven on the Julien system, and therefore, in continuation of our information as to what is going on in this direction in America, we this week give some account of the work of the Julien Company in New York.

There are now eight cars in actual passenger service on Madison-avenue, through the heart of New York, to City Hall or the Post Office. The route is somewhat similar in traffic and the difficulties to be overcome to a trip from Hyde Park to the Bank. It is expected that the number of cars will immediately be increased to 12 in service, with two or more in reserve.

Of the cars now in service, No. 1 has been running since the 17th September, No. 3 since the end of September, and No. 2 for the past six weeks, the remainder more recently. It is remarkable that, although the cars are subjected to the severest tests in the shape of grades of five per cent., curves with a radius as low as 21 per cent., with a rising gradient at that, and passengers to the number of nearly 70 at a time on the car, none of the cars have ever broken down on their journeys, but have always come back to the station without any extraneous assistance. In three or four instances the company have had stoppages arising from the usual mechanical difficulties, but in such instances they have always been enabled to correct the evil in a few minutes, so that the car could proceed on its journey. The chief, and probably now the only remaining difficulty to be removed is that arising from the commutator brushes. One of the greatest, and almost only yet unsolved, problem among electrical engineers has been the proper adjustment of brushes on commutators, to get continuous, uninterrupted, and satisfactory work without excessive sparking, especially under varying loads. This company's only difficulties have arisen from this source. They are gradually overcoming the difficulty, however, and in some of the motors they have recently constructed (where the commutator has wider segments and mica insulation) they have encountered no difficulty whatsoever.



The cars are giving great satisfaction to the public, and have worked so well that a large future sphere of action, especially in large cities, seems to be accepted as a foregone conclusion.

One of the most interesting questions relates to knowing the cost of running a car. Of course the company have not gone far enough yet in their work to be enabled to give any accurate or reliable data as to the cost of maintenance, but they inform us that, so far as the batteries are concerned, the system is an assured success; because the batteries are produced at a price so low as to enable railroads to replace them with economy, even though their economy should be less, much less than that now claimed for them. The Julien Company have now a very large number of installations for lighting, and some of those installations are now approaching nearly two years of service, and while cells and plates have, of course, been replaced, yet the percentage of such replacement has been very small. They state unhesitatingly, less than one-third, and undertake to say that the percentage will be much smaller during the next two years, both because the consumer has learned to take care of the battery, and because a better battery is now made than then. In their street car work no deterioration in the batteries has yet been noticed.

The standard car (18ft. body) carries 144 cells of the type B battery. The cell is a small one, weighing about 32lb. in all, but it has the capacity of at least 300 watts. On an average discharge of 35 amperes, it is seen that the car starts from a station with about 58 electrical h.p. hours capacity. Within the last few days the cars have been making three round trips, or 36 miles, on one charge of battery. It is found that it takes 15 h.p. hours for each round trip. They have not yet attempted a fourth trip, for the cars, being in daily service, have no time to experiment, and there are no instruments to measure the amount of energy remaining in the battery at the end of any trip. The only guide is the voltage, and that is a very uncertain one. The aggregate voltage of the battery at the start is about 320. The fall is found to be very gradual and very slight. At the end of the third trip, or 36 miles, the day previous to the communication made to us on December 7 the voltage of each cell was still above two; there were nearly 300 volts still remaining.

It may interest readers to know that the experience of the Julien Company with their batteries has upset many of the theories read of in books in relation to the abuse of a battery. One battery has been in service on an experimental car about a year and a half, and has recently been on daily passenger service on car No. 3 for four months. As the motors of car 3 are rather inefficient, this battery has been subjected to great abuse. There is not a trip the car makes that the battery is not called upon several times to yield 120 amperes in parallel. A good deal of the active material has been shed by the positive plates, but not one of them has buckled, nor become disintegrated. The battery still has a capacity of about 250 watts for each cell. The plates of this battery were hand-spread, and were made when the company was young at the business. The batteries now made, and which have been in service on the new cars for nearly three months, have so far shed none of the active material—absolutely none. Of course

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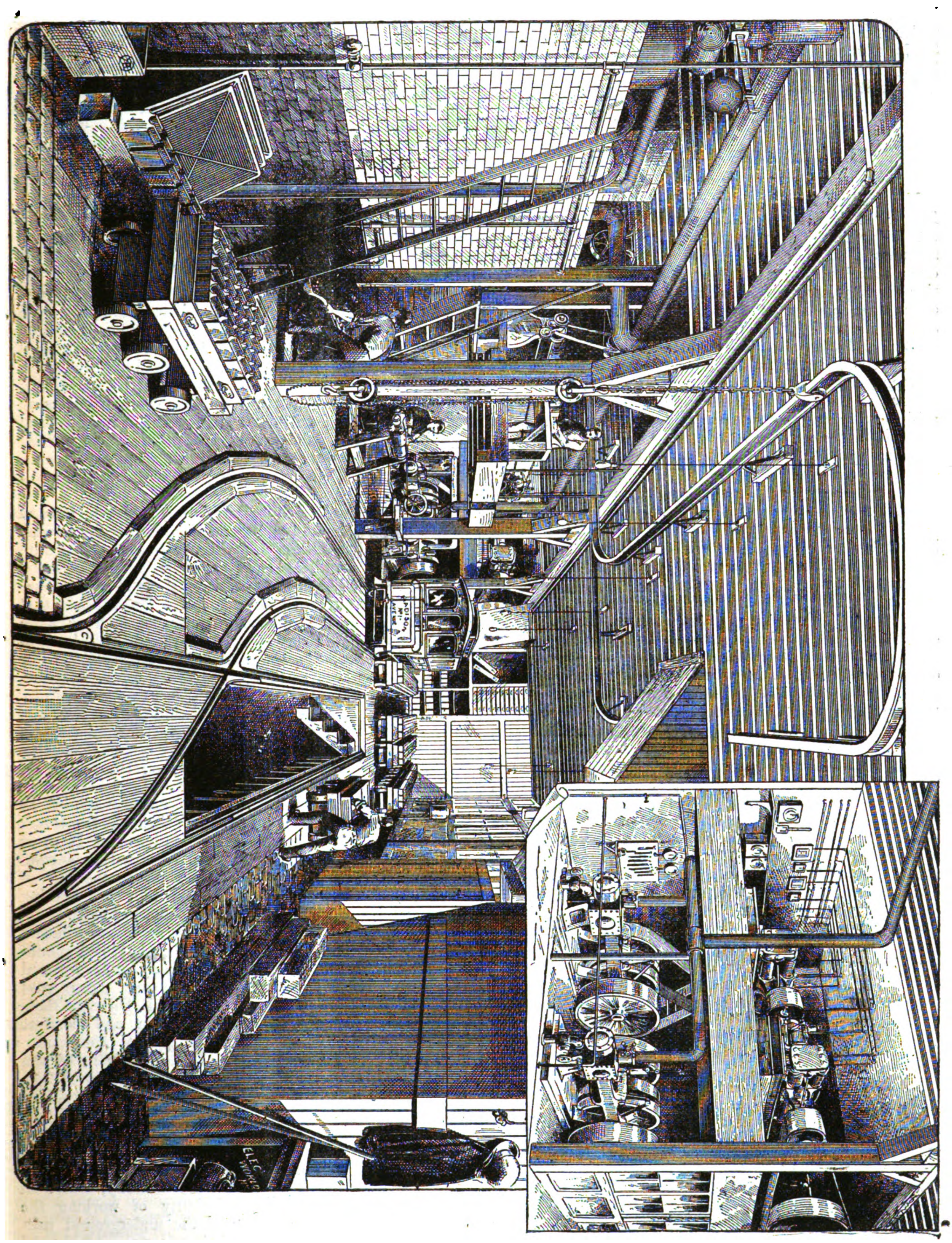
their capacity of 300 watts continues right along. Now that the cars make three round trips on one charge, the battery is changed but once a day—a great saving in time and labour. This change is made by means of a hoist on either side of the car, and of the same length as the car-body. Each hoist is run by a small electric motor. It is provided with two shelves; one to receive the discharged battery when the car comes in, and the other containing the charged battery for service. These batteries stand on shelves at the back of the hoists. Shelves on either side, about 15ft. high, contain enough batteries to run six cars. They are the same width as the hoists. The batteries are set in trays which rest on rollers on the shelves as well as on the hoists. The rollers are worked by means of a wheel at the end of the shelf-rack. By turning this wheel, all the battery is moved on to the hoist at the same moment, and in turn from the hoist into their position on the car. By this device six cars are run from a space 54ft. long, 11ft. wide, and 15ft. high. Those cars would require 125 horses to do the same work, so that a comparison can be made between the space



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required for that number of horses, and the moving of them about, and that occupied by the batteries. Moreover, the hoist and shelf-racks are quite inexpensive and simple of construction.

The cars after their day's work are taken into the car-house by means of a little shifting electric locomotive, which is called a "shifting engine." It has a small body, 8ft. long, mounted on a small truck of a 4ft. 8½in. wheel base. The body contains 74 cells, grouped in four series, and one 10 h.p. motor.

THE PROGRESS OF ELECTRICITY.

Major Flood Page has written the following letter to the *Times*: "It is a matter of common observation that the use of electricity is spreading, and, owing to the accounts that have appeared in the *Times* on the central station of the London Electric Supply Corporation at Deptford, which is being built for the supply of a large portion of London with the electric light, and to the activity of the Chelsea, Kensington, Metropolitan, and other electric companies who are putting up central stations, the public at last begin to believe that some movement is being made.

"But as there are many who, though interested in the subject, have no opportunity of ascertaining the amount of progress that electricity is making, I trust that you will grant me space to bring together a few facts connected with the increase of electric lighting in England—facts which, thanks to the electrical journals, are known to the electrical world~~, but not~~ to the general public.

"So vast is the metropolis, and so little do we know what is going on in our midst, that, doubtless, it will be a matter of astonishment to many of your readers to be informed that there are actually in operation nine central stations, some small, but others of considerable importance, in London; while 12 other central stations are in progress, more or less advanced, making a total of 21 stations in operation, or in course of construction or organisation, in the county of London. And when we look to the provinces, we find that central stations have been started, and are working, with more or less success, at places as far apart as Brighton, Barnet, Blackpool, Chatham, Eastbourne, Hastings, Leamington, Liverpool, Taunton; and that provisional orders are being sought either by municipalities or by companies in Bath, Bradford, Bournemouth, Cardiff, Derby, Exeter, Edinburgh, Glasgow, Ipswich, Liverpool, Swansea, Sheffield, Waterford, Lynmouth, Folkestone, and Reading; while plans are maturing for central stations in Manchester, Southampton, Okehampton, and other places, among others, the City of London, which it is proposed to divide into three sections, giving a chance of lighting to three separate companies. Some of these may not be carried out, and some may fail; nevertheless they make a goodly array for a beginning.

"We may expect that, during this and the next session of Parliament, we shall see a considerable number of provisional orders for electric lighting granted—the exact number I dare not attempt to predict, but it is safe to say that we may hope to see not less than 50 district central stations working under provisional orders before very long.

"I know no way of measuring the progress that is being made so simple, and at the same time so convincing, as comparing it with the early years of the gas industry. We know, from a return which was made to Parliament in 1847, that between 1810—the year in which the first Gas Act was passed—and 1820, only 20 gas companies received their Acts, and it seems indisputable that electrical central stations far in excess of this number will be at work long before ten years have elapsed from the passing of the Electric Lighting Act.

"It is not possible to arrive at the amount of capital already invested in electric light companies in the United Kingdom, as a very large proportion of the work is being done by private companies; but the limited companies engaged in electric lighting have a nominal capital of more than £4,000,000, of which about half has been called up; while it appears, from the return to Parliament already quoted, that from the year 1810 to the year 1850, 134 gas companies were established, with an aggregate capital of £6,602,010, so that it seems manifest that within 40 years from the date of the first Electric Lighting Act, a very much larger sum will have been invested in connection with electricity than was invested in gas during the 40 years from the passing of the first Gas Act. But some of your readers may say it is all very well to talk about central stations and the progress of electricity; but gas companies cover the kingdom and, in every instance, pay good dividends. Are the electric companies ever going to pay dividends? I hope and believe that a majority of the central stations will be so managed as to pay, and that the allied electrical industries will also pay fair dividends; but we are not exempt from the difficulties which beset new industries any more than the gas companies were 70 years ago.

"The words which Mr. Burdett uses of that great and successful company the Gas Light and Coke Company (the chartered company) of London might, with but little alteration, be used of the electric companies to-day:

"'The early struggles of the chartered company were very great. It had to carry out on a gigantic scale, and on commercial principles, what had hitherto been matter of experiment only, and almost everything had to be invented, calculated, designed, and constructed in order to arrive at a successful issue. For years the rental was little more than nominal; and when, at a later period, it had achieved a position of some public utility, and was realising a fitful profit, the shares were almost always at a heavy discount, and the dividend, when any was paid, seldom exceeded 6 per cent.'

"It is well to bear in mind that in 1820 the price of consols ranged from 65 to 70, and that we no longer speak of the sweet simplicity of 5 per cent., but of the painful simplicity of 'Goschens' at 2¾ per cent.

"But electric lighting is not the only use to which electricity is being put; and there is no reasonable doubt that electricity will be used for motive power as much or more than for lighting. Everybody is aware that in Ireland, at Blackpool, at Brighton, and elsewhere, electric railways or tramways have been working successfully for some years, not to enumerate those which are working successfully outside the United Kingdom; and within the last few days an electric omnibus has been making experimental trips in London, and the owners hope during the summer to place their first batch of these horseless cars on the streets for daily work in competition with the omnibuses.

"We are about, however, to see electricity applied to locomotion on a larger scale in London than has heretofore been tried in England, as Messrs. Mather and Platt, of Manchester, have got the contract for constructing a complete electric railway for working the traffic in the City of London and Southwark Subway, and they are making arrangements for running 2,200 train miles per diem.

"Lord Bury's company are about to make experiments on the Metropolitan Railway, and in, fact, I think I should not exaggerate in saying that we may look forward with good hope to seeing before many years pass over our heads the Metropolitan and District Railways worked by electricity. The gain and comfort to the many millions who make use of these railways would be incalculable. I am not unaware of the difficult and complicated nature of the many problems, scientific and commercial, which will have to be solved before this desirable end is attained. Nevertheless, I venture to think that the scientific difficulties will be more easily overcome than those connected with the expense of making such extensive changes as will be involved in the substitution of electricity for steam. Naturally, wise men express doubt as to the practicability of working the enormous and unequalled traffic of the underground railways by means of electricity, but there are men connected with electrical engineering who are studying the question, and will be prepared to deal with this desirable and suggestive development.

"I have purposely restricted my remarks to the work going on in England, although I can speak from personal observation of the progress which has been, and is being made throughout the length and breadth of Europe. A

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large portion of Paris has within the last few weeks been parcelled out for lighting by six companies. Central stations are at work in Moscow and St. Petersburg, Berlin, and many towns in Germany, in Vienna, and in numerous towns in all parts of the Continent. The United States maintain their lead, and with characteristic energy keep ahead of all other countries in electrical development.

"Sprague's and other motors are now being used in the United States to an extent that it is difficult for us to realise, and the motor companies are being taxed to their utmost capacity to keep pace with the demand. Germany is not behind, and the town of Metz will serve as an illustration of the practical use to which the military authorities are applying electricity, for electric light is used for lighting the railway stations and the railway approaches, for lighting the ramparts, search lights being used for illuminating the surrounding country. The barracks are electrically lighted, and the Government have portable plant for accompanying troops while skirmishing at night.

"Within the last few months an electrical section of the London Chamber of Commerce has been organised—already there are nearly 100 members of the section—and the discussions which take place are eminently practical and useful. In this we see electricity for the first time taking its place as one of the recognised industries of the country.

"A few weeks ago the Society of Telegraph Engineers, which has done useful scientific electrical work for 17 years past, adopted the new title of the Institution of Electrical Engineers, and Sir William Thomson, F.R.S., the president, speaking at the general meeting of the newly-named institution last month, said that the members and associates numbered 1,550, and, referring to the many branches of electricity with which the institution was occupied, said: 'With all these grand subjects of applied practical science for our province, I think the Institution of Electrical Engineers may feel that it has a great and noble dominion.'

"The Board of Trade, with wise discretion and sound judgment not always to be found in public departments, is giving its earnest and cordial support to all well-considered plans for extending the use of electric light, and if central stations are before long put upon a sound basis, no small credit will be due to the cautious judgment which the officials of the Board of Trade have exercised.

"I think, therefore, that all who are interested in the progress of electricity—and who is not?—may well be hopeful. For my own part, I look forward to a sure and certain development of electricity in all its branches, and think that before long we shall be as familiar with electric lighting and electrical motors, and perhaps phonographs, as we now are with its use in connection with house bells, telephones, and telegraphs."

ELECTRICITY: LIGHT AND POWER.

BY HOLROYD SMITH.

(*Continued from page 79*).

Though there are numerous applications on the continent surpassing what we have in this country, we have to cross to the other side of the Atlantic for public works on a large scale. In New York most of the public streets and squares are lighted by electric arc lamps, and many of the new towns, or cities as they call them, have no gas works; they realise the superiority of electricity, and adopt it. Even the staid, old-fashioned Quaker city of Philadelphia possesses an installation which, of its kind, is unsurpassed. The Girard College, or Orphan Home, the grounds of which cover several acres, have distributed about them tall columns of light ironwork, surmounted with a cluster of five-arc lamps in clear glass globes covered with reflectors. They are so high as not to dazzle the eye by their brilliancy, and powerful enough to illuminate all the grounds and the streets and houses in the neighbourhood, not with a light equal to day-time, but surpassing the best effect of an American full moon.

Perhaps the grandest display of electric light in the world is the torch held aloft in the hand of the Statue of Liberty, presented by the Republic of France to the Republic of America, that has been erected on an island in New York Harbour. It stands there defying the fiercest tempest, flashing a light of welcome to all seeking the shores of the newer and larger world.

The praise given to America needs some qualification, and it is only fair to ask, why has the practical application of electricity there so far outpassed the rest of the world? Though it is largely due to the national characteristic of dash and go-ahead, it is not altogether due to these qualities. An American can "calculate" as well as any man; he is not beaten in this particular even by the Hebrew brotherhood—which is perhaps the reason why so few of the tribe of Judah and Benjamin reside there—and being able to calculate, he finds that, light for light, electricity is cheaper than gas. This applies to America more so than here, first because gas there costs about 12s. a thousand instead of 2s. 6d. as here, and, secondly, because the authorities will permit a rough-and-ready method of erecting poles and running wires that would not and ought not to be countenanced in a civilised country, thus of course cheapening the cost of installation. And further, in England nearly every hamlet has its gas plant, which means so much money sunk; there new towns and districts are springing up every day, and having no capital account to write off there is no hesitation in adopting a new method.

Another feature of the American character may be cited as explanatory of the rapid adoption of electricity in that country—viz., the high cost of labour, and as a result the welcome and encouragement given to men who can devise means of lessening the necessity of employing labour. An inventor in America is looked upon as a valuable man to be encouraged, whilst here the custom is to shun and suppress and hinder as far as possible, the natural result being that our best men are drawn there, where their efforts are appreciated and rewarded.

The American tendency to adopt has resulted in obtaining for them a credit for originality more than they deserve. The public are apt to associate an invention with those who develop and bring it into practical use, so let it be here stated that English scientists owe very little to the Americans, whilst the American practice is mostly built upon English science. Theories formulated and experimentally proved by English electricians have found no remunerative field here. They have been communicated through the press, or otherwise, to the United States of America, understood, realised, put into practice, made a commercial success, large companies formed, then brought over here and sold to speculators of the Stock Exchange, who, not able to understand, did not appreciate the fundamental truth as propounded by the originator.

As an illustration of this may be cited the telephone. No capitalists in the old world would find the necessary money for working out the conception and making it a reality; but American ability, enterprise, and legal skill enabled the facts known to scientists here to be developed and so patented, that a large, and strong, and profitable monopoly has been obtained. Having mentioned the telephone, it will be well to correct a popular misconception respecting it. It is generally supposed that the voice is transmitted from the speaker to the hearer. This is not so. No sound or sound-waves are transmitted as through a speaking-tube. It is not the voice of your friend you hear, it is the imitation of that voice, an imitation so like the original it is difficult to realise that it is only a reproduction.

To understand how a telephone really works, the reader must remember the leading principles given as the A B C in the commencement of this article. There it was stated that, by waving a piece of iron in front of a magnet round which a copper wire was wound, electric energy was made to pulsate through the wire. Now, if the piece of iron is a thin sheet, so thin as to be affected by air pressure, then you have only to talk in front of that iron sheet whilst it is held near to the pole of a magnet, and the bulging and straightening of the thin plate has the same effect upon the magnet as waving the iron—viz., it causes electric pulsations to pass through the wire surrounding it. Now, that wire has only to be wound round another magnet, no matter how far away, and the pulsation of electricity will alter the strength of that magnet, causing it to attract and relieve the sheet of metal in front of it—viz., make it vibrate in the same way that the speaker's voice made the first sheet vibrate, and the vibration of the second plate acting upon the air reproduces the sound.

The order therefore is—the speaker's voice vibrates the plate or "diaphragm" of the transmitting telephone, the vibrating plate causes pulsations in the copper wire; those pulsations passing round the magnet of the receiving telephone, vibrate its diaphragm, which reproduces the sound.

The reproduction is so like the original it would be possible for a listener in Manchester to recognise the voice of the speaker in London.

Some idea of the commercial value of this instrument may be given from the statement that in England over £4,000,000 is invested in telephone exchange companies, and the shares of most of them are at a premium.

Whilst on the subject of popular errors it will be well to mention the gravest—viz., the credulity that has enabled a number of unprincipled men to do a large and profitable business in electric health appliances on the fallacious statement of their curative effects. Too strong a protest cannot be raised against such trash, and readers before investing their money in any advertised wonder-working belts had better ask the opinion of someone uninterested in the sale and with sufficient electrical knowledge to be able to advise. Electricity may be life, but

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even taking that as a fact, it does not make a piece of red flannel with a few strips of crinoline steel stitched into it a life-saving apparatus.

The scientific papers have of late been very strong on this subject, but unfortunately such papers are seldom read by the general public, who are the victims of this charlantry.

When Anderson, the wizard of the north, was in the height of his popularity, one of the wonders of his exhibition was a little electric carriage that ran to and fro on a table in front of the stage, and he used to prophesy that some day carriages would be run in the public street so propelled. That day has come, and it has fallen to Lancashire, the home of co-operative societies, to have the first successful electric tramway ever made; and the many thousands who yearly visit Blackpool (in addition to the usual numerous attractions of that health-giving place) have now the satisfaction of being taken from end to end of the fine esplanade in commodious tramcars driven by electricity.

No horses, no steam-engines, to the casual observer nothing, but the cars running to and fro propelled by some unseen power, stopping, starting, going quickly or slowly at the driver's will, up hill and down hill, sunshine or shower, full or empty, winter and summer, for the last three years, those cars have run, proving, beyond the possibility of a doubt, that not only can electricity be used, but also that, by the employment of electricity, the work can be done at a cheaper rate than by any other means.

It is only natural to suppose that the reader will hardly be content with a mere statement of facts, but will probably want to know how it is accomplished; and to better understand this, it will be well briefly to consider what had previously been done.

Referring again to the A B C, it will be remembered that an electromagnet will attract a bar of iron as long as it is energised by the passage of a current through the surrounding wires, but as soon as the current ceases, the magnetic action ceases, and the piece of iron is let go. This was the principle of the earliest electric motors, and they were constructed as follows:

Across the surface of a wheel or drum, a number of iron bars (usually 10 or 12) were placed with a space between them three or four times the width of the bar; on either side of the drum an electro magnet was placed, with the poles nearly touching the bars; the spindle of the drum was provided with a cam or other device to make and break the flow of electricity from the battery, so set that when a bar is a little distance away, the magnet is energised, drawing the bar rapidly towards it; but as soon as it gets opposite the electricity ceases, and the impetus of the bar carries it past beyond the range of the magnet, and brings another bar within range, when the magnet is again energised, drawing it forward; thus bar after bar is attracted, and the wheel made to revolve. Little motors of this type can be seen in every shop where scientific instruments are sold, and it was the kind used by Anderson in his demonstrations previously referred to.

For reasons that cannot easily be explained without becoming too technical, this motor is far from economical, and when more powerful machines were wanted a different construction was resorted to—namely, the pulling action of a coil of wire upon a bar of iron described at the commencement of this article.

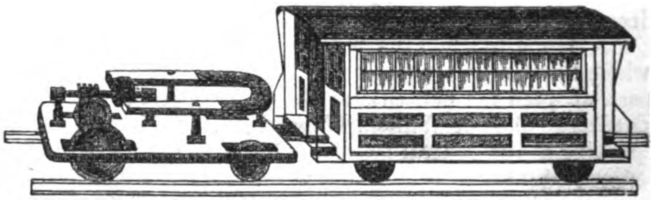
A large motor of this description was constructed in 1850 by Prof. C. G. Page, of the Smithsonian Institute, Washington, which developed over 10 h.p. He sought to apply his motor to locomotion, and he actually constructed an electric locomotive to demonstrate the practicability of his scheme. But he never achieved much success, as might have been foreseen. Among the improvements which Prof. Page introduced was that of making each solenoid double, so that the arms of a U magnet could slip into them, instead of one single bar. As the solenoids attracted most strongly when the cores were almost out of them, he wound his solenoids in short sections, and a sliding commutator, worked by the motion of the cores, successively cut out the sections of coils which the cores had entered, and transferred the current to others ahead of them, and thus the range of attraction was greatly increased.

Prof. Page, it is interesting now to recall, made the trial trip with his electromagnetic locomotive on Tuesday, April 29, 1851, starting from Washington, along the track of the Washington and Baltimore Railroad. His locomotive was of 16 h.p., employing 100 cells of Grove nitric acid battery, each having platinum plates 11in. square. The progress of the locomotive was at first so slow that a boy was enabled to keep pace with it for several hundred feet; but the speed was soon increased, and Bladensburg, a distance of about 5¼ miles, was reached, it is said, in 39 minutes.

When within two miles of that place the locomotive began to run, on nearly a level plane, at the rate of 19 miles an hour, or seven miles faster than the greatest speed theretofore attained. This velocity was continued for a mile, when one of the cells cracked entirely open, which caused the acids to intermix, and, as a consequence, the propelling power was partially weakened. Two of the other cells subsequently met with a similar disaster.

The professor proceeded cautiously, fearing obstructions on the way, such as the coming of cars in the opposite direction, and cattle on the road. Seven halts were made, occupying in all 40 minutes; but, notwithstanding these hindrances and delays, the trip to and from Bladensburg was accomplished in one minute less than two hours. The cells were made of light earthenware, for the purpose of experiment merely, without reference to durability. This part of the apparatus could therefore easily be guarded against mishap. The great point established was that a locomotive on the principle of Prof. Page could be made to travel 19 miles an hour. But it was found, on subsequent trials, that the least jolt, such as that caused by the end of a rail a little above the level, threw the batteries out of working order, and the result was a halt. This defect could not be overcome, and Prof. Page reluctantly abandoned his experiments in this special direction.

In this and all previous experiments the source of energy was an electric battery carried by the car, and the above statement, taken from an American record, shows that practical success is hardly to be expected from batteries so employed. Some other means had to be found for supplying the motor with the necessary energy, and Mr. Thomas Hall, of Boston, United States of America, claims to have been the first to think of using the rails for this purpose. The accompanying illustration is taken from the original woodcut of the locomotive.



HALL'S ELECTRIC CAR.

The block was made nearly 37 years ago, and is thus described in an American book:

"The engine was on the principle of an electromagnet revolving between the poles of a permanent magnet. The armature had a worm on its shaft which matched into a gear attached to the driving-wheels, the latter being insulated by ivory. The track was laid in 5ft. sections, and was above 40ft. long and 5in. wide. Under the platform of the car was a pole-changer attached to a lever. When the engine reached the end of the track it ran against an inclined plane, which reversed the pole-changer and sent the engine to the other end of the track, where the same thing was repeated. Thus the engine was sent automatically from one end to the other. The current, produced by two Grove cells, was, it is well to note, conveyed to the engine by the rails. Mr. Hall says that in 1852 he made for Dr. A. L. Henderson, of Buffalo, a model line of railroad with electric engine depots, telegraph line, and electric railroad signals, together with a figure operating the signals at each end of the line automatically."

This, he states, was the first model of railroad signals or trains worked by telegraph signals.

Now, it will be easily seen that when the "dynamo" was developed, and it was found that it not only produced electricity, but if supplied with electricity produced power, the field was open for practical work; and with the knowledge of what had already been done, there was no great advance in the electric railway constructed by Dr. Werner Siemens in 1879 and exhibited at Berlin, where the current was taken to the motor on the car by one rail and returned by the other. The little line on the sands at Brighton is, generally speaking, a repetition thereof, and is an excellent specimen of this method, but upon reflection it will be seen that such a plan is inadmissable in the public streets, where horses and carriages are continually crossing and recrossing the rails. For if the rails are conducting a current sufficient to work the number of cars that usually work in a town, then should a horse put one foot on one rail, and another foot on the other rail, it would be instantly killed. This led to the use of the Berlin line being prohibited. And further, if the line is of any length, then the leakage of electricity from rail to rail, through the earth instead of passing through the motor on the cars, would be so great as to render it useless or excessively wasteful. The system, therefore, fails on the three points that are essential for street tramways—viz., safety to the public, efficiency, and economy.

The cheapest and simplest method is to convey the current to the cars by an overhead wire supported on poles, and this is largely used in America, where the questions are, Will it work? and will it pay? and appearances are out of it altogether. Though the employment of overhead conductors would be a great economic gain, if adopted on all our English tramways, it is hardly to be expected that the English public would put up with the unsightly thing used in the States. But the unsightliness is quite unnecessary. The supports can be made orna-

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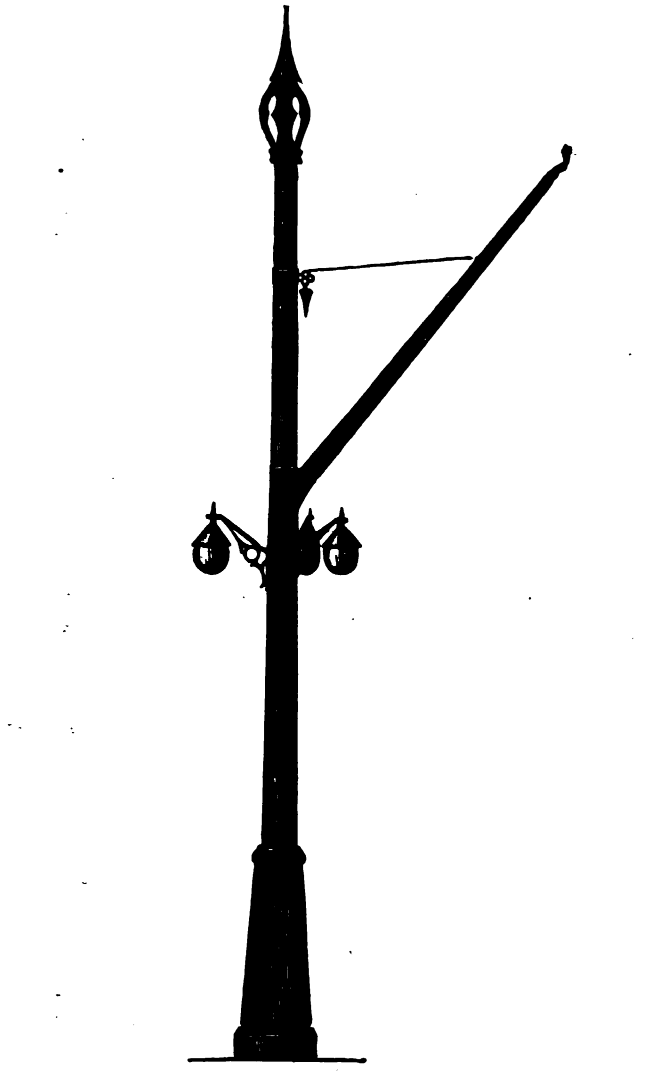
mental as well as useful, and there is no reason why this method should not be adopted in country towns.



Pole for Overhead Conductor.

The accompanying sketch illustrates one erected in a seaside resort, for the purpose of demonstrating what could be done.

(To be concluded.)

PHYSICAL SOCIETY.—Jan. 26.

Prof. Fuller, F.R.S., in the chair.

The thanks of the society were tendered to Mr. Freeman for presenting to the library a rare and interesting work, "Réflexions sur la Puissance Motrice du feu et sur les Machines propres a développer cette puissance," par S. Carnot, ancien élèvede l'École Polytechnique.

Dr. S. P. Thompson read three notes on polarised light, entitled respectively, **"The Structure of Natural Diffraction Gratings of Quartz," "Ahren's Modification of Delezenne's Polariser," and "The Use of Two Quarter Wave Plates in Combination with a Stationary Polariser."** Two microscope slides of iridescent quartz (prepared by the late Mr. Darker), which have recently come into the possession of the author, exhibit remarkable peculiarities. Both act like diffraction gratings—one as if the rulings were about 12,000 to the inch, and the other about 26,000 to the inch. On examining the specimens by the microscope, it was found that the parts which exhibited the grating effect showed a spindle-like structure, and by micrometer measurements the dimensions of the spindle-shaped bodias were determined to be from $\frac{1}{1000}$ to $\frac{1}{2000}$ of an inch in diameter and $\frac{1}{100}$ to $\frac{1}{200}$ long. These were much too large to cause the effects noticed, but on closer examination it was found that the bodies were crossed at right angles by fine markings, the distances between which are in close accordance with those deduced from the spectra produced. As a probable cause of the phenomenon the author mentioned a recent paper by Prof. Judd "On the Production of a Lanellar Structure in Quartz by Pressure," and suggested the possibility of making diffraction gratings by such means. Ahren's modification of Delezenne's polariser consists of a total reflection prism, combined with glass plates and black glass mirror, arranged so that the polarised beam is parallel to the original one. The combination of plates and mirror is adopted so as to give enough light and still keep the polarisation sufficiently good. One or two plates laid over the mirror is found to give the best results. The fact that a beam polarised by reflection is not coincident with the original beam, renders it inconvenient, if not impossible, to rotate the polariser, and to overcome this defect the author has arranged two quarter wave plates, one of which may be rotated. The first plate circularly polarises the plane polarised beam, and the second (or rotating one) replane—polarises it in any desired plane. Objects were shown on the screen to illustrate the degree of perfection attainable by using the new polariser in combination with the two quarter wave plates.

A **"Note on Relation between Magnetisation and Speed in a Dynamo Machine"** was read by the same author. In a note presented to the society in June last, it was shown that $\Sigma \rho \, \Sigma R = 4 \pi n C S$, where $\Sigma \rho$ and ΣR are the magnetic and electric resistances respectively, n=speed, and C and S the numbers of armature and field windings. By writing the equation in the form $\frac{4 \pi C S}{\Sigma R} = \frac{\Sigma \rho}{n}$ it is seen that when the electric resistance is maintained constant, the magnetic resistance is proportional to speed.

Prof. Herroun read selections from a paper **"On the Divergence of E.M.F.'s from Thermochemical Data."** The fact that the E.M.F.'s of voltaic cells do not always coincide with calculated values has not hitherto received a satisfactory explanation, and this paper describes an experimental research bearing on the question. Several suggested explanations are given. In some cells the anticipated chemical change does not occur, and some metals become coated with oxide or subsalts; others are effected by dissolved gases, and the hydration or solution of the salts formed may supplement or diminish the E.M.F. of a cell, as well as the absorption or evolution of sensible heat. The question of absorption and evolution of heat is the one chiefly dealt with. If such actions do take place, the total heat evolved by passing a definite current through the cell must depend on the direction of the current, and by enclosing the cell in a calorimeter the difference should be detected. The total heat developed by a current C, in t seconds is $= \frac{C^2 r t \mp e C t}{J}$ where r is the resistance of the cell and e the divergence of the observed from the calculated E.M.F., the − or + sign depending on the direction of the current. In the case of mercury cells, which are usually said to give about half a volt excess E.M.F., the heat was found to be independent of the direction of the current. The heats of formation of mercury salts were then reinvestigated, and the results showed that Julius Thomson's numbers (the ones usually accepted) were greatly in excess of the true values. This accounts for the difference between the observed E.M.F.'s and those calculated from Thomson's numbers. A copper silver nitrate cell was tested in the calorimeter, and the reversible heat effect agreed closely with that deduced from the "thermovoltaic constant," or divergence of observed from calculated E.M.F. Other experiments on tin, lead, nickel, iron, and cadmium cells are described, and the chief conclusions arrived at are: I. The primary factor in determining the E.M.F. of a voltaic cell is the relative heat of formation of the anhydrous salts of the two metals employed. II. That this E.M.F. may set up chemical changes of a different direction and character from those predicated from the heat of formation of the dissolved salts. III. That the E.M.F. set up by I. may be, and usually is, supplemented by the energy due to the hydration or solution of the solid salts, and may have values which accord with the heat of formation of the dissolved salts. The absorption, or evolution, of sensible heat depends primarily on the attraction between the salts and water, combined with the heat of solution. Finally, the author states that the E.M.F. of a cell gives a more accurate measurement of chemical affinity than data derived from calorimetric observations.

COMPANIES' MEETINGS.

CUBA SUBMARINE TELEGRAPH COMPANY.

The thirty-fifth ordinary general meeting of this Company was held last week at the offices of the Company, Old Broad-street, E.C., Mr. Joaquin de Mancha presiding.

The **Chairman**, in moving the adoption of the report and accounts, said it would be remembered that they had carried forward £1,195 from last year's accounts. To that they had been able to add, from the working of the six months under review, £20,708, while there had been an increase of 3,440 in the number of messages. These results, he thought, must be regarded as highly satisfactory. Out of that sum they proposed to pay to pay a dividend at the rate of 10 per cent. on the preference and of 9 per cent. per annum on the ordinary shares—a dividend which, he hoped, would be maintained in the future. The French cable, with which they had been so long threatened, had now been laid from Venezuela to San Domingo, Hayti, and thence to Cuba; and the Directors, with the effective assistance of the manager and secretary, had done all they could to see that the rights of the Company were not trenched upon. They had sent out a supply of cable and other appliances by which it was hoped the manager would be able to effect any repairs in the Cienfuegos-Batabano section of their cable, which was now showing signs that might shortly necessitate them. If any greater injury happened to the cable than they anticipated they might ultimately have to duplicate it, and that was the reason why they had built up so large a reserve fund, which now stood at £84,000, and which, he thought, would be equal to any future emergencies.

Mr. Alexander F. Low seconded the motion, which was carried unanimously, and the dividends recommended were afterwards approved.

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CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the past week amounted to £4,871.

Western and Brazilian Telegraph Company.—The traffic receipts of this Company for the past week, after deducting the fifth of the gross earnings payable to the London Platino-Brazilian Telegraph Company, were £3,772.

Submarine Telegraph Company.—The accounts of this Company for the half-year ending December 31, 1888, show a balance, subject to audit, which enables the Directors, after adding 15 per cent. of the gross receipts to the reserve fund, to recommend a dividend at the rate of 16 per cent. per annum.

NEW COMPANIES REGISTERED.

River Plate Electricity Company, Limited. — Registered by Ashurst, Morris, Crisp and Co., 6, Old Jewry, London, E.C. Capital £500,000, divided into 49,900 shares of £10 each, and 1,000 shares of £1 each. Object: to enter into and carry into effect the agreements made with Walter Richard Cassels, and with the Rosario Electric Lighting Syndicate, to generate, produce, and deal in electricity or electric force for lighting or other purposes. The first subscribers are:

	Shares.
G. J. Toy, Athole House, Tottenham	1
W. Hamilton, 12, The Avenue, Brondesbury, N.W.	1
H. C. Hudson, 16, Mentone-road, Highbury New-road N.	1
F. Belcher, 3, Ceeley-villas, East Finchley	1
J. B. Birch, 15, Eckington-road, Stamford Hill	1
F. G. Bregan, 11, Thurlow-road, Hampstead, N.W.	1
E. T. Batwright, 23, Sutton-place, Hackney, E.	1

The first Directors shall be appointed by the subscribers to the memorandum of association, and shall each hold at least 50 ordinary shares in the capital of the Company. The remuneration shall be the sum of £1,000 per annum, and one-tenth of the surplus profits remaining after payment of 10 per cent. per annum.

PROVISIONAL PATENTS, 1889.

FEBRUARY 4.

1856. **Improvements in the method of and means for the regulation of dynamos.** John Harold Woodward and Edmund Scott Gustave Rees, 70, Market-street, Manchester.

1961. **Improvements in microphone apparatus for increasing and transmitting sounds by means of earth currents, also by means of chemical batteries.** Robert Henelade Courtenay, 6, Anerley-street, Battersea Park-road, Surrey.

2003. **Improvements in electric-regulating apparatus for use in connection with steam-engines and other motors and dynamo-electric machines.** Alfred Lyster Shephard, 45, Southampton-buildings, London.

2006. **Improvements in apparatus for receiving payments and permitting the administration of electricity in exchange therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (David Richmond Johnston, Belgium.)

FEBRUARY 5.

2044. **An improved type writer and telegraphic apparatus, applicable in combination therewith.** Carl Hans Wolf Stielow, 433, Strand, London.

2056. **Improvements in electric stop valves.** Robert Wellens, 53, Chancery-lane, London.

2066. **Improvements in the manufacture of electrodes for secondary batteries or accumulators.** Leonard Paget, 45, Southampton-buildings, London. (Complete specification.)

2071. **Improvements in electric systems.** Anthony Bernerd Ferdinand, 77, Chancery-lane, London, W.C. (Complete specification.)

2079. **An improvement in plates for secondary voltaic batteries.** Arthur Harry Norman, 28, Southampton-buildings, Chancery-lane, London, W.C.

2080. **Improvements in and relating to portable electric batteries and in electrodes therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (Lucius Thaddeus Stanley, United States.) (Complete specification.)

2082. **Improvements in or relating to telephone call-boxes.** William Phillips Thompson, 6, Lord-street, Liverpool. (Amenzo Griffith, Henry Anderson Burbank, and William Herbert Jordan, United States.)

FEBRUARY 6.

2137. **Improvements relating to magnetic telephony.** Eugene Gwosdeff, 6, Bream's-buildings, Chancery-lane, E.C.

2141. **An electric meter.** Caspar Baur, 28, Southampton-buildings, Chancery-lane, London, W.C.

2145. **An improved electrical apparatus for lighting cigars or pipes, and for other purposes.** William Green, 54, Fleet-street, London, E.C.

2151. **Improvements relating to electric batteries.** William John Woodward and Frederick Henry Judson, 45, Southampton-buildings, London.

FEBRUARY 7.

2168. **Improvements in or appertaining to electric meters.** William Phillips Thompson, 6, Lord-street, Liverpool. (Henri Owen Tudor, Grand Duchy of Luxemburg.)

2169. **Improvements in or relating to electric signalling apparatus for railways.** William Phillips Thompson, 6, Lord-street, Liverpool. (Eugène Jacques Jérome de Baillehache, France.)

2176. **Improvements in materials and methods of preparing the same for bases of electrical instruments and for other electrical purposes.** Frederick Lawrence Rawson, 11, Queen Victoria-street, E.C.

2199. **Improved electric periodical contact making switch.** Arthur Douglas and Frederick Smith, 4, Dane's Inn, Strand.

2205. **China or porcelain cap or socket for incandescent electric lamps.** Edward William Lancaster, Albert Works, Graham-street, Birmingham.

2206. **Improvements in the electro-deposition of metals, specially applicable for depositing on fragile articles or coating, plating on, or forming articles of irregular surface.** Thomas Phillip Christopher Crampton, Edward Gardner Colton, and The Medical and Scientific Apparatus Company, Limited, 38, Holborn Viaduct, E.C.

2231. **Electric fog and danger-signalling apparatus for railways.** Charles Adams-Randall and Walter Herbert Cook, 15, Montpelier-square, Brompton, London.

FEBRUARY 8.

2243. **Electrical connections attached to railway locomotives, and to connect to a metal plate affixed near the rail, arranged by a metal wire brush.** William Andrews, 34, Broad-street, Nottingham.

2252. **The improvement of instruments for measuring currents of electricity.** John William King, 13, St. John's-square, Clerkenwell, London, E.C.

2276. **Improvements in the construction and arrangement of primary batteries.** Emile Guitton, 166, Fleet-street, London. (Marcel Sappey, France.) (Complete specification.)

2297. **Improvements in primary and secondary transportable galvanic dry elements.** Castle Smith, 54, Fleet-street, London. (Wilhelm Louis Frederik Hellesen, Denmark.)

2299. **Improvements in apparatus for measuring electric currents.** Lucien Alfred Wilhelmine Desruelles and Raphael Fénelon Ovide Chauvin, 45, Southampton-buildings, London.

FEBRUARY 9.

2313. **Improvements in means of applying electricity for therapeutic purposes.** Henry Newman Lawrence, 24a, Regent-street, London, S.W.

2331. **An improved apparatus for economically effecting the double decomposition of certain substances by the aid of electricity.** William Henry Dowland and Walter Mills, 54, Glengall-road, London, S.E.

2349. **Improvements in and relating to electric appliances for illuminating the dials of clocks and watches.** Thomas Hoxland White, 20, High Holborn, London, W.C.

SPECIFICATIONS PUBLISHED.

1881.

3369. **Electric lighting.** Hedges. (Amended and complete specification.) 8d.

1888.

609. **Determining poles of electrical circuits, &c.** Berghausen. 8d.

2666. **Dynamo machines, &c.** Sherrin. 8d.

3590. **Electrical transformers.** Statter. 8d.

3710. **Electro-magnetic motors.** Tweeddale. 8d.

3841. **Telephonic apparatus.** Laurie. 8d.

4940. **Dynamo-electric machines.** Parker. 8d.

13,778. **Telephone apparatus.** Vail and Seely. 11.

15,252. **Battery plates.** Madden and Madden. 8d.

17,340. **Electro-depositing cells.** Justice. (Smith.) 8d.

17,535. **Electrically operated domestic apparatus.** Davis. 8d.

17,645. **Secondary batteries.** Currie. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¾
12 Feb.	2/0	— fully paid	5	4¾
14 Nov.	0/4½	Con Telephone & Main	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	19
......	...	House-to-House	4½	—
30 May	2½%	Oriental Telephone	11	½
26 April	4/0	Reuter's	8	7½
......	...	Swan United	3½	2½
12 July	12/0	Telegraph Construction	12	43
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	14⅛

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NOTES.

Blackpool.—There is some probability of a scheme for the extended lighting of the Blackpool Promenade by electricity being agreed upon.

St. James'.—The St. James's Vestry adhere to their resolution not to consent to the application of the House-to-House Company for a license.

Karlsbad.—A central station is to be put down at this watering place by Messrs. Ganz and Co., similar to the station just erected by them at Marienbad.

Electric Railway at Baden.—Plans have been prepared for an electric railway to be shortly constructed between Baden and Vöslau, Lower Germany.

Electric Sugar.—The electric sugar gang are now in gaol. It is stated that there is still some £16,000 assets available, enough to pay a dividend of 16 per cent.

Electric Tramway for Spain.—The Brush Corporation have booked a contract for the application of their system of electric traction to an important tramway line in Spain.

Lille.—The Municipality of Lille has entered into arrangements with the two gas companies in the district for the construction of two central stations for electric lighting.

Submarine Telephone.—The first submarine telephone line is being established between Buenos Ayres and Montevideo by the Belgian company, Mourlon and Co. The cable will also transmit telegraphic messages.

Rome.—The Municipality of Rome are considering the question of public lighting by electricity. They contemplate acquiring the present central stations of the various companies, and extending the plant so as to light the entire city.

Electric Railway Crossing Signals.—Messrs. Siemens and Halske have introduced on the German railways a system of electric bells for level crossings. When a train is within 1,500 yards of the crossing the bell rings violently until the train has passed the crossing, giving ample warning of danger.

Electric Light in the Lake District.—Steps are being taken to form an electric light company at Keswick, the project having the support of several of the most influential residents. A survey has been made, and it is expected that the works will be on the banks of the Greta, the river supplying the motive power. A prospectus will be issued to the public shortly.

Electrically Welded Bale Ties.—In the South American cotton-fields large amounts of waste ends of the iron hoop used for tying the cotton bales have hitherto been wasted or sold for scrap. The Thomson-Houston Company have applied one of their electric welding machines to utilise these short ends by welding together into sufficient lengths. The saving thus introduced is very considerable.

"Brush" Combined Electric Light Sets.—The Anglo-American Brush Electric Light Corporation, Limited, have just secured an important contract for the supply of about 40 sets of combined engines and dynamos of their special design, and have now in hand orders for nearly 50 sets of apparatus of this pattern. The design has met with much favour from the European Governments since its introduction, and has been largely adopted for lighting ships of war and other vessels.

Milan.—The following particulars are given in *Elettricita* of the central station in Milan: 1,075 incandescent lamps of 8 c.p., 4,839 of 10 c.p, 6,817 of 16 c.p., 158 of 32 c.p., 1 of 50 c.p., 227 Thomson-Houston arc lamps, and 152 Siemens arc lamps, making a total of 12,890 incandescence and 379 arc lamps. The station also supplies a certain number of electric motors, for which a current is supplied equal to the rate of ½d. per ampere-hour, which comes out about 4d. per horse-power per hour.

The Telephone on the Railway.—A practical experiment was lately made on a French line of railway to show that communication by means of the telephone may be made from a disabled train to the neighbouring stations. On the line from Noyelles to Saint-Valery, where a telephone wire runs along the line, a train stopped in open country. With the aid of a portable telephone connected to the wire, communication was then made with the two stations before and behind, which acted perfectly.

Proposed Central Station at Sofia.—The Electric Section of the London Chamber of Commerce notifies us that Her Majesty's Agent and Consul-General at Sofia reports that the municipality of that capital has decided to light the streets of the town and the ministries, consisting of ten houses with about 20 rooms in each, with electric light. Tenders for that purpose will be received by the Municipality of Sofia up to the 13th of April; and it is desirable that communications should be made in French or German if possible.

Telegraphists for the Cape.—We understand that the Cape Post Office authorities have recently asked Mr. Walliker to recommend several telegraphists for service in the colony, with the result that in the course of a few days five expert and experienced telegraphists, of from five to nine years' service, will be transferred from the Birmingham Post Office. The terms of the engagement are such as appear to offer them favourable opportunities of advancement, in addition to which their service under the Home Government is allowed to count for pension.

Houses of Parliament.—A small steam-engine and dynamo, capable of working about 120 extra electric lights, have been erected at the Houses of Parliament, thus increasing the total number in the building to 620. Seventeen of the additional lights have been placed in one of the reporters' writing-rooms, and the remainder are supplied to the members' entrance lobby, staircase, and corridor. After Easter the light will probably be extended to the Commons' lobby, St. Stephen's Hall, the offices immediately adjoining the House, and several of the Ministers' and reporters' rooms.

Electricity in Mining.—An interesting paper was read by Mr. F. Brown on the transmission of power by electricity before the annual meeting of the South Staffordshire Mining Engineers, dealing with the wider application of electricity to mining. Mr. Brown advocated the use of electrical coalcutters, which could be mounted on a truck and taken to any part of the mine by two men. Mr. Brown gave several instances of the successful application of electricity to mining in this country, and cited one instance in which it was estimated that £500 a year was saved by its use

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Electric Fire Alarms in Paris.—A new arrangement of electric fire alarms has been designed by M. Petit, controller-general of telegraph lines in Paris. With the old forms of fire alarms it was only necessary to break the glass and press a button, and many false alarms were given by practical jokers. In the new applications a little door has to be opened to give the alarm, and the same movement puts in action a strong electric bell placed inside the box. It is impossible to stop this bell for some moments, and the giving of the alarm by this means renders it impossible for a false signal to be sent without the public and the policemen being aware of it.

Dry Storage Batteries.—It may be remembered that in describing Dr. Gassner's dry battery, it was stated that the battery could be reversed and used as a storage battery. An accumulator of this nature is being brought out in Berlin under the name of the Welcker storage battery, having a jelly instead of liquid as electrolyte. The battery is said to be a very light one in weight, and it has been proposed to form a company to distribute stored electricity by carts for electric light and other purposes. No very exact details of the enterprise are yet published, but if a practical dry storage cell could be introduced, there would be a large field of usefulness for it.

The New Central Railway at Glasgow.—Arrangements for the construction of a new central line at Glasgow will be commenced shortly. The engineers mentioned for construction are Messrs. George Miller Cunningham, Edinburgh, and Charles Formans, Glasgow, and the consulting engineer will be Mr. Wolffe Barry, London. The new railway will extend from the east to the west end of Glasgow, running for the greater part of its length in line with the River Clyde and under several of the principal thoroughfares. It is seven miles long, and of this distance about six miles is underground. The present underground railway company in London is meditating the adoption of electric traction, and the Southwark Railway, now building, has definitely adopted electricity. Would it not be well for the Glasgow Central Railway to begin in the direction which all underground city lines will eventually have to adopt?

A New Notion in Casing Junctions.—We are always ready to welcome any little improvement in the details of electric light installations, and we are pleased to notice an improved junction in the wood casing for wires, which has been sent to us by Mr. Fred. Bathurst, of 111, King Henry's-road, N.W. At any junction of wires to the mains, one branch wire has always to cross the main of opposite potential. To make this quite safe is a point worthy of greater attention by electrical contractors, and in the device of Mr. Bathurst we have a small semi-circular block of wood with one groove in it, which is placed upon the casing at the point of junction. The branch wire, after the joint is made, crosses in this groove quite away from the opposite main, and a wood cover, in the form of half a ring, turned to match the casing, fits down over this. The joint reminds one of the little curves crossing the opposite wire always drawn in diagrams of electric wires, and it makes a junction perfectly safe from possibility of danger.

Value of "V."—The measurement of "*v*" by Sir William Thomson and Profs. Ayrton and Perry, communicated to the British Association at Bath, was too small (292) on account of the accidental omission of a correction regarding the effective area of the attracted disc in the absolute electrometer. When this correction is applied, their result is brought up to 298, which exactly agrees with Profs. Ayrton and Perry's previous determination by another method, in Japan. Prof. J. J. Thomson's result is 296·3. It is understood that Rowland found 299. The result of Sir William Thomson's latest observations, founded wholly on the comparison of electrometric and electromagnetic determinations of potential in absolute measure, is 30·1 legal ohms, or 31·04 Rayleigh ohms. Assuming, as is now highly probable, the Rayleigh ohm is considerably nearer than the legal ohm to the true ohm, the result for "*v*" is 300·4 million metres per second. Sir W. Thomson does not consider that this result can be trusted as demonstrating the truth within ⅓ per cent.

The Thomson-Houston Systems.—The Thomson-Houston Company is one of the most far-reaching organisations of electric manufacturers, electric light—arc and incandescent—electric railways, and the welding system. These have been spread abroad through the length and breadth of the world with astonishing success. Especially is this lately the case with electric railroads in the States, and intending enterprisers in tramways would do well to inspect the catalogue of the Thomson-Houston electric railway system, just issued by Messrs. Laing, Wharton, and Down, New Bond-street. It is most handsomely got up, and illustrates views of electric railways now working successfully at Toronto, Lima, Port Huron, Scranton, Ansonia, and other places in America, with details of the system and working expenses. The Thomson-Houston electric light catalogue, now ready for issue, we have already fully noticed—a handsome and comprehensive book. The catalogue, or prospectus, rather, of the welding system, is also issued, and contains information with reference to the applications on every side of this, the latest branch of electrical industry.

Underground Wires on the Continent.—It is reported that an interesting case will shortly occupy the attention of the law courts of Luxemburg. The city of Luxemburg granted, in 1864, to the local gas company the exclusive right of laying down gas-pipes in the streets, and of supplying the city with gas. The Amsterdam representatives of the firm of Siemens Bros. lately made arrangements to provide Luxemburg with the electric light, and asked the municipality for authority to erect overhead wires or lay down underground conduits, and permission was granted without hesitation. The gas company considers that this permission constitutes a breach of contract, and have requested the municipality to have the wires removed, claiming damages at the same time. The company assert that the intention of the contracting parties in 1864 was to give to the company the exclusive right of lighting the city. The municipality reply that this monopoly only applies to gas. As the introduction of the electric light depends upon a decision on this point, the result of the application of the company to the courts is awaited with some degree of eagerness.

Telegraph Line Inspection.—Colonel Mallock's tour of inspection of the Indo-European telegraph line has come to a close, so far as Persia is concerned. Leaving Simla on October 20th, the Director-General of Telegraphs arrived at Bushire at the end of that month, and began his long ride "along the wires." He reached Teheran, by the way of Shiraz and Ispahan, on December 3rd, having ridden 717 miles in 32 days, including halts for inspection purposes at various stations. After a stay of 16 days at Teheran, he started again for Bagdad by

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the Koom route, riding the 500 miles in 24 days. He chose this route to shorten his journey, and to avoid the snow on the highlands between Teheran, and the Persian Gulf. Colonel Mallock was due in Calcutta about Feb. 10th. It has been fully decided that he is to have a year's extension of office, the reason being that the Government of India, having only lately acquired the Indo-European telegraph, find it desirable to utilise his personal knowledge of the line. Otherwise he would be obliged to retire, under the 55 years' rule. Colonel Mallock will still only be officiating as director-general, as Sir Lepoc Cappel's leave does not expire till December next.

St. George-the-Martyr Vestry.—A special meeting of this Vestry was held on Tuesday, prior to the transaction of the ordinary business, for the purpose of considering the following recommendation of the Roads Committee: "That this Vestry assent to the granting of a license by the Board of Trade to the House-to-House Electric Lighting Company, Limited, authorising that company to supply electricity within this parish." Mr. Stevens, the engineer to the company, was in attendance, and made a lengthy statement as to the system adopted by the company. He explained that the company used underground mains, and, as to street lighting, said the company would be prepared to supply the parish at the same rate as, if not less than, the gas company. Mr. Layman moved, and Mr. Emary seconded, that the recommendation of the Roads Committee be adopted. In answer to Mr. Titcomb, the clerk (Mr. W. H. Millar) said the license would only give the company powers for seven years. Mr. Brazier asked whether, in the event of the company coming into the parish, their property would be liable to assessment. The Clerk : Certainly. The motion for the adoption of the committee's recommendation was adopted unanimously.

Army Signalling and Torpedo Warfare.—The means of army communication in the field, as well as the development of torpedo warfare, have during the last decades made such vast progress, that both may be regarded as new subjects of military science. An index of publications on military communications and on torpedo warfare, compiled by R. Von Fischer-Treuenfeld, late Director Army Telegraphs, etc., is published by Alabaster, Gatehouse, and Co. (80 pages, 3s.), and should prove very useful to military engineers. The first part contains 680 titles of literary works, which are grouped in 29 classes, comprising the following subjects: Military telegraphy, signalling, field post, military aeronautics, military photography, land and submarine mines, torpedo boats, electric light for military purposes, ballistics, lightning dischargers for military buildings, range-finders, and cryptography. The second part contains 340 names of the authors of the publications, arranged in alphabetical order. The index has been compiled in order to facilitate researches with regard to the above-mentioned branches of military science, and thus to further their study and practical development, and the titles of publications are given in their original languages, so that the index may be looked upon as an international one.

Woodward Storage Car.—The Detroit battery is used on the new storage car made by the Woodward Electrical Company for Brooklyn. The car is equipped with 84 cells, with hard rubber jars, having a capacity of 300 ampere-hours. Each cell has 17 plates, but a larger size, containing 19 plates and having a capacity of 400 ampere-hours, will shortly be placed on the car. A series motor is placed under the car, which is mounted on six wheels, and the power is transmitted from the motor to the axles by means of two friction wheels. Two pairs of wheels are movable, and connected to a lever on the platform. When the said lever is operated the movable pair of wheels are brought up to the friction wheels, attached to the motor shaft between them, and the car is thus set in motion. By this means the start can be made very gradually, though quickly, and without jar or shock. On the platform are also placed a main battery switch and regulating switch. The arrangement is such that when the brake lever is applied the batteries are automatically cut out at the same time. When starting, the brake lever is released by the foot, while at the same time the batteries are again automatically placed in circuit, and the car starts with the full power. The car is brilliantly lighted by three 16 c.p. incandescent lamps.

Brussels.—The city authorities at Brussels, says the *Bulletin International de l'Electricité*, have already received several propositions with regard to the electric lighting of the central portion of the town. The American Thomson-Houston Company, represented in Belgium by M. Humbert, offer to light gratuitously the Boulevards Anspach and Du Nord, on the condition that the town authorise them to lay wires under the public streets for lighting the large buildings round the Bourse and the market. For this supply the Thomson-Houston Company have made arrangements to construct a central station in a neighbouring building. Two other generating stations would be constructed, one in the rue des Bouchers, the other in the rue Royale. The first would light the Galeriès Saint Hubert, and the whole of the buildings in the vicinity. It is stated that M. Vlierboom had also proposed to establish a station here, and had secured a large number of orders, but when he began to fix the boilers and dynamos the town authorities intervened, because the site of his station had been chosen without their consent. This project has now the support of a group of financiers, and the Thomson-Houston Company will probably find them serious competitors. The other proposed station by this company would light the banking offices of the rue Royale as well as the Theatre du Parc.

Electric Power in India and the Colonies.—The *Indian Engineer* calls the attention of its readers to the spread of electric railways in America, with the hope that it may suggest some action in this direction in India. The water power, for instance, it is suggested, which now runs to waste along the Darjeeling Railway would possibly go far towards working this line by electric traction, and at many of the hill stations there is ample power now running away uselessly, which might be turned to good account in lighting or other purposes. There is no doubt that they are moving far too slowly in this direction, not only in India, but in all our colonies; but this is to a great extent the fault of our English electrical engineers. When we compare the attitude of the industry in England with America, we might do well also to look at the map of the two countries, and we then realise what we too often forget—that in new undertakings England's greatness in commerce depends, and must depend, to an enormous extent upon its colonies, the British possessions generally. When English electrical firms attempt to exploit this vast domain in the same manner as the American companies do the States, then there may be some possibility of English electrical activity rivalling that of the New Continent. England is England

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quite as much by the extent of its colonies as by the activity of its inhabitants, and it would be well if electrical engineers recognised this attitude to a far greater extent than at present they appear to do.

Progress at Deptford.—The large transformer station, on the Ferranti system, at Deptford is now the point of attraction of all eyes in the electrical world, and all are anxiously awaiting the start with a similar feeling to that often enough experienced by electrical engineers in the early days on the starting of a new installation. "Lighting up" is a common enough event now, and we know exactly what to expect, but the arrangements for lighting up here are of sufficient grandeur and novelty to bring the same feelings into play again. We are pleased to be able to report that the work at Deptford is actively progressing. The roof has been on some time, and the two "small" engines of 1,500 h.p. each are laid down. Boiler-power to the extent of 6,000 h.p. is ready, but the dynamos and electrical connections will not be placed till the last, when the building is dryer. None of the 10,000 volt mains have yet been laid. This, however, will not be a long job, and will be done in as short a time as possible, so as not to inconvenience the railways along which they are to be run. Arrangements are made for a start about the end of April, and the wires will first be led to Charing Cross distributing station, and connection made from there to a large number of houses to the number of many thousands, which are already wired for the light. The machinery at the Grosvenor will not be disconnected for some little time, till the outstanding needs have been fully supplied.

The Electric Engine on the Elevated.—The electric engine "Benjamin Franklin" has been running continuously since January 28 (with the exception of two days during the strike) on the Elevated Railroad, New York, taking its place among the steam-engines, and winning golden opinions from the absence of smoke, steam, and cinders. It draws the standard train of four long cars, with average load of passengers, weighing in all 80 tons, with gradients of nearly 2 per cent., with an average speed of 15½ miles per hour, as against 13¼ of the steam-engines. The electric engine alone at times attains the speed of 30 miles an hour, developing over 120 h.p. No mishap or reverse of any kind has occurred; no heating of journals, magnet coils, or commutator. It takes its place between two ordinary trains and runs on schedule time. It does not, however, stop between the termini, not yet being furnished with air brakes, and stopping by hand brakes would absorb too much time. At present no delay is occasioned, and no trip is missed. Three of the leading financiers of America—Messrs. Gould, Sage, and Dillon—are at the head of the Elevated Railroad, and are carefully investigating the system from the purely commercial point of view. Numerous careful experiments and tests are being made with the current, load, and steam-engine diagrams, which may be published shortly. If this powerful company decide to adopt electric engines for their city traffic, it will give an immense impetus to the spread of heavy electric railways throughout the world; and we commend their action to the notice of Sir Edward Watkin and the Electric Traction Company.

The Submarine Cables.—The Central News says: "The attitude of France in regard to taking over the cables of the Submarine Telegraph Company has placed the British Post Office in a position of considerable difficulty. M. Coulon insists on the laying of new cables instead of taking over the old ones, and has just given formal notice that France intends to grant to the Submarine Company a further prolongation of the term for the working of the cables between the two countries until the difficulties existing between the two Governments are removed, or until new Anglo-French cables have been manufactured and laid. This practically makes it impossible for the British Post Office to take over the working of the French cables on 1st April, the date previously arranged. On the other hand, the Post Office is bound, by agreement, to commence working the German and Dutch cables by the above-named date, and if those Governments insist upon their contracts being rigidly adhered to, the continental traffic in telegrams will be divided between the Submarine Telegraph Company and the General Post Office, a state of affairs almost certain to lead to friction in the working. Last week a conference was held at Cologne between the heads of the Telegraph Departments of Germany, Holland, Belgium, and Great Britain (Mr. Lamb representing the British Postal Telegraphs), to arrange for the further working of the wires between Great Britain and those countries; but whether any revision of existing arrangements was then definitely decided upon has not yet transpired. From the opinion of experts, however, it is believed to be impossible for the Government to take over the working of the German and Dutch cables by April 1, and the same opinion is even more strongly held in respect to the Belgian cables."

Electrical Stress.—Prof. Rücker, at the Royal Institution, last Friday night, delivered a lecture, in which he discussed the effects of the introduction of electrified conductors into non-conducting or nearly non-conducting liquids. The subject had been studied by Faraday, Kerr, Quincke, W. Holtz, and others, but various difficulties had prevented some of the more striking phenomena being shown in experimental lectures. The lecturer and Mr. Boys last year devised a set of apparatus which made the exhibition comparatively easy. Faraday's magnetic lines of force could be shown by the aid of iron filings; but the corresponding experiment in the case of electrical lines of force in a liquid was more difficult, because the liquid was thrown into violent agitation, and the solids used tended to cluster about one of the poles. These points were illustrated by experiment, and the lines of force were realised by means of powdered antimony immersed in ether. The tendency of the lines of force to become shorter, and to separate the one from the other, was also illustrated, and from this the fact was deduced that a body subject to electrical stress assumed temporarily a kind of crystalline structure. Kerr's and Quincke's experiments on the passage of polarised light through carbon bisulphide were then discussed. Kerr's experiments depended upon the fact that since the electrical stress was a tension along the lines of force, and a pressure at right angles to them, a substance in which such a stress was produced assumed a semi-crystalline condition in the sense that its properties along and perpendicular to the lines of force were different. Light was therefore transmitted with different velocities according as the direction of vibrations coincided with or was perpendicular to these lines, and the familiar phenomena of the passage of polarised light through crystals might be imitated by an electrically-stressed liquid. These researches were exhibited with various modifications and extensions.

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Electrical Signalling on Board Ship.—The advantages which the electric signalling apparatus of Mr. J. B. Willis offers over mechanical and pneumatic contrivances are so marked that the Admiralty have, says the *Pall Mall Gazette*, given orders for fitting a number of vessels with it. A commander hitherto has not always been certain that his orders to the engineers or steersman have been observed and carried out, but by this telegraph the signal must be acknowledged, so that the officer is ensured against mistakes. The instrument works to a large extent automatically, the simple movement of a handle doing all that is required, so that there is less to do, as well as absolute certainty on the part alike of the officer, the engineer, and the man at the wheel. The relief is so great that the captain of a merchant steamer who has had the apparatus in use for eight or nine months has declared that he would sooner be at the expense himself of fitting his vessel with the system than return to the mechanical telegraphs. In addition to the engine-room and steering telegraphs, there is a revolution order telegraph for signals between the captain and engineer in giving the number of revolutions at which the engines are to work. This will prove of great utility in warships for fleet and line manœuvres, and would be a great advantage in all ships, especially in entering port, and where it is necessary to have the engines quickly changed by a few revolutions—for instance, in cable laying and repairing, or in sounding operations. A number of transmitting instruments can be worked to a single receiver in the engine-room, so that they can be fitted up in various parts of the ship. The cable connecting the instruments is laid under the water line in ships of war, so that they are free from danger in action, and if one or more of the instruments were destroyed, the efficiency of the others would not be impaired. The apparatus, as already stated, is being fitted up in a number of Her Majesty's ships, and the naval attachés of foreign Powers have been inspecting the installation which has been fitted up at the works of the manufacturers, Messrs. Elliott Bros., St. Martin's-lane.

Plymouth Tramways.—An important meeting of the Plymouth Town Council took place last Friday to consider the report for the formation of a new tramway. The report of the Works Committee was presented with the agreement with the new tramway company. The use of locomotive steam-engines is prohibited. Certain streets are to be widened, and two years are allowed to do the work, and the promoters are to prove that £8,500 of the capital has been offered and accepted before commencing work. The question of horses, cable, and electricity was freely discussed, some members being in favour of the old-fashioned horse; others in favour of the cable system—quoting the example of Birmingham, evidently not knowing that Birmingham has decided for electric traction. Considerable interest was evinced for electric tramways, and a telegram was read from Gravesend stating that a trial of the electric system there was satisfactory. Mr. May, in reply to criticisms that horses were not accustomed to see a car coming along by itself, referred to the electric omnibus which had been run in London. Mr. Moon, speaking on the motive power to be used, said he believed in the future that tramways would be worked by electricity, and not by cable power. No company would be so ill-advised as to lay out an engine-house and cable for the whole of their system, when in the future electrical power would be generally adopted. Alderman Harland expressed the sentiments of the Council when he said that they ought to have the report of some responsible authority as to the working of the motive powers mentioned, as at present they knew very little about them. They ought to apply to the proper authorities in other towns where the systems were used, and ascertain whether there was any objection to their being introduced into a town like Plymouth. The mayor then put the motion, leaving it open to adopt either cable or electricity, and the report was unanimously adopted. We shall look to our electrical tramway engineers that Plymouth, having the chance to start fair with an electric tramway, has the best means of judging of its advantages over other means of traction.

Drake and Gorham's Catalogue.—Almost every private installation, and many public ones, have now a set of secondary batteries as a necessary adjunct. Of electrical engineers fitting up these batteries very few have had anything like the experience of Messrs. Drake and Gorham, who have a working arrangement with Elwell-Parker, Limited, under royalty to the E.P.S. Company, to manufacture accumulators to their own specification and embodying their patented improvements. Everyone, therefore, who has to use secondary batteries would do well to secure a copy of the new catalogue which Messrs. Drake and Gorham have just issued, in which these batteries are fully illustrated and described, together with all the accessories they have found necessary to devise for the convenient manipulation of battery installations. The improvements claimed for the "D & G" cells are the process of "burring" the lips of the cavities; the use of a special alloy unoxidisable in acid; the dense nature of the grids due to the rolling process; patent method of holding the lugs; use of ebonite insulating frames so arranged that the lugs of positive and negative plates are placed at different heights to prevent oxide causing short-circuiting; and the use of Elwell-Parker special oxides, which prevent blistering. Prices are given for various sets of complete batteries. Drake and Gorham's patent excess indicator is also illustrated, and of switches, a number of very useful forms of their ring contact switches, a peculiarly solid and satisfactory switch for heavy currents. A combined charge and discharge switchboard, with these switches, is very useful, and this, mounted on the same base with cut-outs, steelyard ammeter, etc., is illustrated in various forms for battery installations. Besides these, we have Drake and Gorham's battery testing voltmeters, with long range, from 0 to 3·5 volts, a very useful instrument; and hydrometers for testing the acid, one form of which reads from 1·140 to 1·180 over a 5in. scale, giving great facility for delicate testing. Their patent disc ammeter, a recent form of instrument with a solid copper tube split in screw form as conductor, possesses good features of simplicity and of accuracy in the neighbourhood of other currents, and is a solid and convenient instrument. We note the list of Captain Cardew's instruments, the patents for which have been purchased by Messrs. Drake and Gorham. These include the celebrated Cardew voltmeter, a safety switch for high-tension current; electrical speed-counter, to indicate speed of rotation at a distance; and a recording voltmeter of great utility for engineers of central stations. Along with the catalogue Messrs. Drake and Gorham also issue, in neat pamphlet form, their instructions for running secondary batteries, in which the necessary directions are carefully and fully described with illustrations. This contains, in a few sheets, a considerable amount of very useful information about the management of accumulators.

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ON CERTAIN PHENOMENA CONNECTED WITH IMPERFECT EARTH IN TELEGRAPH CIRCUITS.*

BY A. E. KENNELLY, ASSOCIATE.

Since the earliest days of commercial telegraphy—the days that first reaped the labours of Sœmmering and Steinhill, Gauss and Weber, Cooke and Wheatstone—the substance of our planet has been impressed into such universal conducting duty, that now scarcely a circuit closes, be it across an ocean or be it across a meadow, but embraces its share of the earth in its completion; and the task thus imposed is generally borne so readily and executed so perfectly that, until the existence of the eavesdropping telephone, it was really doubted whether in truth the earth could or did conduct the current entrusted to its care.

Considering, then, the great obligations telegraphy owes to the earth—that the existence of some hundred thousand miles of metallic conductor, at present in daily telegraphic operation, implies in a certain sense the corresponding twin existence of an equal length of terrestrial conductor ready made by Nature; that it has even been possible to telegraph over a space of which the metallic conductor formed but a very proper fraction—the cases that are met with where the earth fails to fulfil its part excite astonishment more by their rarity than by the force of those laws whose mandates they obey.

Almost all such cases of imperfect earth are, we know, traceable to some fault either in the earth connection itself or in its immediate neighbourhood; and a remedy is found by adequately increasing the surface area of the buried electrode, or the conductivity of the ground in its vicinity; so that they are not really failures of the earth's conduction, but failures in securing the necessary degree of connection with the earth's mass.

There are, however, other cases, brought about by conditions more deeply seated and more rarely met with, which will occupy our present attention.

A paper by Mr. James Graves, "On Vibrations due to Earth-Plates," was read before this Institution in January, 1875, and it will be seen that the phenomena therein described are probably related to those that will be presently detailed. Although the matter has not occupied the Institution's direct attention since that date, no doubt some of its members will have independently observed similar phenomena, and can bring forward such additional evidence as cannot fail to elucidate a subject at once replete with technical interest and important practical bearings.

These phenomena are presented by the Atlantic cables of the Direct United States Cable Company, with whose permission the facts are laid before the Institution.

The two cables of this company terminating in Nova Scotia run to Ireland and to Rye Beach respectively. Their landing place was originally Torbay, N.S., but they were removed thence to Halifax some eighteen months since.

The diagram shown supplies the outlines and main features of Halifax Harbour. The Irish cable was first brought into the cable-house, situated 40ft. above high-water mark, upon the beach opposite George Island, on the 23rd October, 1887, and it was put in communication with the town office by means of a line cable and a return earth cable, side by side, in an iron pipe. Each cable was 0·7 knot long, had a resistance of 8·3 ω, a capacity of 0·25 φ, and a high insulation. The line cable united with the Irish shore end through lightning guards, while the earth cable made good soldered connection with the shore end sheathing.

Some vibration of the mirror spot, due to electrical disturbance, was noticed on first joining up the circuit at the office through instrument and condensers, but this was at the time attributed to faults which then existed in the cable. Beyond this continual vibration, no noteworthy feature occurred until six days later (29th October), when the Rye Beach cable was landed at the same cable-house, and joined up with the office by a precisely similar pair of cables running through iron piping in the same trench with the other above mentioned. This cable is worked on the double-current Morse system without condensers, and it was immediately noticed that sending to Rye Beach with 12 volts of battery power visibly disturbed the mirror spot on the Irish circuit, although each cable made earth separately through its own sheathing *via* the insulated return cables to the beach. Receiving from Rye Beach did not disturb the mirror, nor did the operation of the Irish cable in its turn affect the less delicate apparatus of the Morse circuit.

The only remedy that could be, or has since been, practically available, without adding to the retardation of the circuits, was the reduction of the Morse battery power on one hand, and the sensitiveness of the Irish mirror on the other, as far as the operation of the circuits would conveniently permit.

After the removal of the faults in the Irish cable, the vibrations of the mirror still continued, and it was noticed that not only these, but periods of disturbance coincident with local meteorological changes, affected the signals more than had been on record with the same circuit when worked previously from Torbay. On this was superposed the interference caused by transmission on the Rye Beach circuit, and the combined disturbance at times made the mirror signals difficult to read.

The Rye Beach shore end was at first laid very near to the Irish cable, and actually over it at one or two points. The cables were, however, subsequently separated, although they still necessarily lie at different points in close proximity. This separation of the cables was found to have sensibly lessened their interference.

The operation of the cables from the cable-house, instead of from the office, was found to produce no change in the nature or degree of disturbance, while experiment failed to produce any visible interference between the trenched cable circuits from office to beach, even on the most delicate instruments.

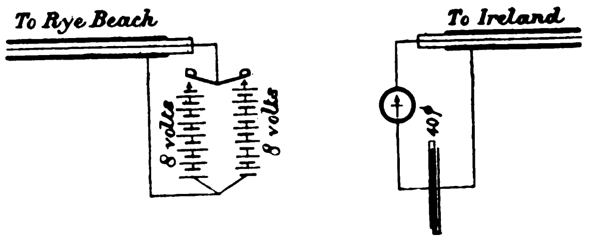
A third cable was then laid from the cable-house across the harbour, and out through the eastern passage in the direction shown on the diagram. It had a total length of 5·8 knots, sheathed up to within half a mile of the sea end. This unsheathed half mile of core terminated in a copper earthplate one yard square, nearly on a line between Thrumcap Rock and Hartland Point. This well-insulated line offered every prospect of securing a good and independent earth by its large terminal plate. When, however, it was joined up at the cable-house with the Irish circuit, in the place of the Irish shore-end sheathing, the interference from the Rye Beach transmission remained as marked as ever.

To determine the nature of this obstinate interference, a series of experiments was made at the cable-house as follows:

All existing connections were for the time dismantled, and only the two cables, the two earth-wires soldered to their respective sheathings, and the core of the third cable, or six-mile earth, were brought up to the testing table.

Fig 1.

Experiment No. 1.



The resistances between these three earth-wire terminals was measured as follows by bridge:

Between Irish sheathing and Rye Beach sheathing ...0·16 ω		All steady.
,, ,, ,, ,, six-mile earth.........65·7 ω		
,, Rye Beach ,, ,, ,, ,, ...65·7 ω		

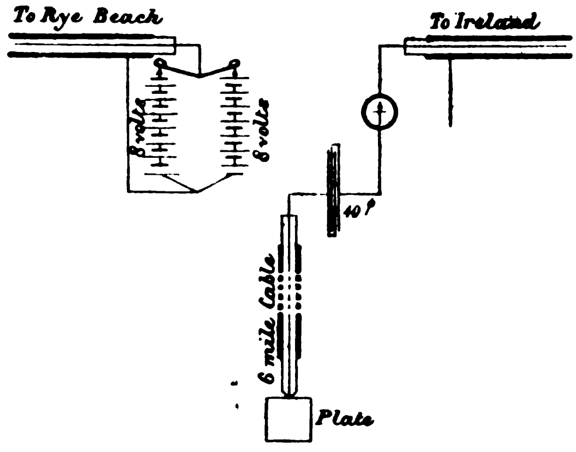
From which the resistance of each sheathing earth connection would, of course, be 0·8 ω, and of the six-mile earth 65·6 ω.

The only apparatus then retained for investigation was a Daniell battery of 14 gravity cells—used with, and sometimes also without, a pole-changer—for exciting disturbance, and a sensitive speaking mirror—used with, and also without, condensers of 40 φ capacity—to render any interference visible.

Experiment 1 (see Fig. 1).—Sending reversals from seven cells into the Rye Beach cable produced vibrations of the spot on the mirror instrument in circuit with the Irish cable, its sheathing, and 40 φ.

Fig 2.

Experiment No. 3.



Experiment 2.—Similarly, sending reversals into the Irish cable, using its sheathing, produced vibrations on the mirror in circuit with the Rye Beach cable condenser and sheathing.

Experiment 3 (see Fig. 2).—Sending reversals into the Rye Beach cable produced vibrations on the mirror in circuit with the Irish cable condenser and six-mile earth.

Experiment 4 (see Fig. 3).—Sending reversals into the Rye Beach cable, using the six-mile earth, produced vibrations on the mirror in circuit with the Irish cable condenser and its own sheathing.

Experiment 5.—Sending reversals into the Irish cable, using the six-mile earth, produced vibrations on the mirror in circuit with the Rye Beach cable condenser and its own sheathing.

Experiment 6.—Sending reversals into the Irish cable, using its own sheathing, produced vibrations on the mirror in circuit with the Rye Beach cable condenser and six-mile earth.

Experiment 7.—Sending reversals on the circuit formed by the six-mile earth, battery, and Rye Beach sheathing, the disturbance on the

* Paper read last night before the Institution of Electrical Engineers.

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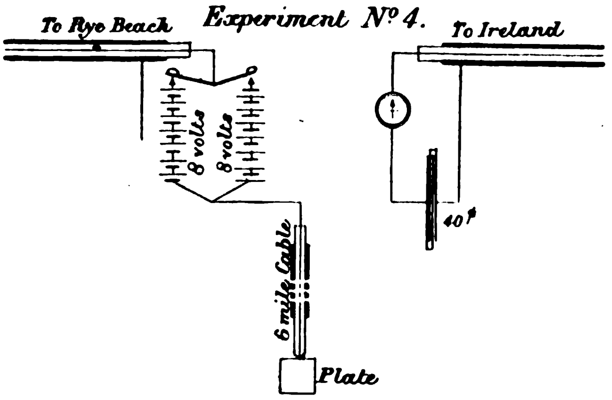
mirror in circuit with the Irish cable condenser and sheathing was more decided than in any of the preceding experiments.

Experiment 8.—Similarly, sending reversals on the circuit formed by the six-mile earth, battery, and Irish cable sheathing, the disturbance on the mirror in circuit with the Rye Beach cable condenser and sheathing was equally great.

Experiment 9.—The two last experiments were repeated with the condenser removed and the mirror in direct circuit between cable and sheathing. The continual vibration of the spot made observations difficult; but during periods of comparative quiescence it was soon determined that the disturbance produced by depressing one of the keys was not of a momentary nature only, but consisted of a small deflection, permanent during the whole period of key application, and of direction depending upon the key selected. It was also ascertained that this deflection was not due to any local electro-magnetic action by

Fig 3.
Experiment No 4.

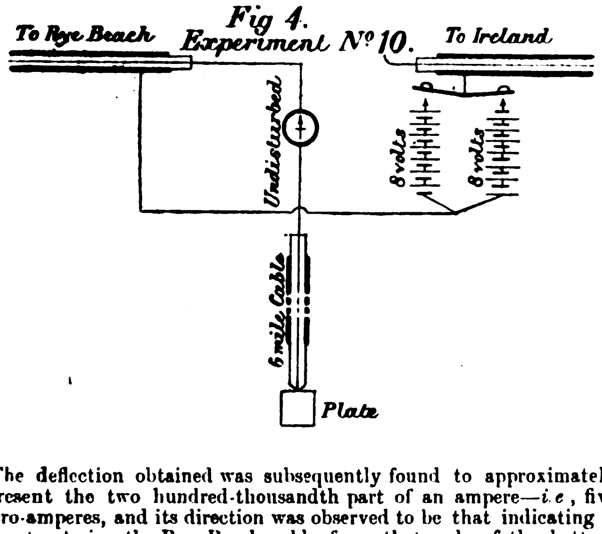


Experiment 10 (see Fig. 4).—On sending reversals between the two cable sheathings in circuit with the battery, no disturbance could be detected on the mirror in circuit with one of the cables and the six-mile earth.

This small steady deflection produced by holding down the key in either of the two cases tried in Experiment 9 was more plainly visible when the mirror was in circuit with the Rye Beach cable, which, besides its shorter length, had no condenser in circuit at the distant station. To obtain some quantitative information regarding the strength of current represented, the 14 cells were connected in series and more careful observations made.

Experiment 11.—Closing the circuit formed by the 14 cells, the six-mile earth, and Irish sheathing, measurements were made of the steady deflection so produced on the mirror joined up with the Rye Beach cable and sheathing.

Fig 4.
Experiment No 10.



The deflection obtained was subsequently found to approximately represent the two hundred-thousandth part of an ampere—*i.e.*, five micro-amperes, and its direction was observed to be that indicating a current entering the Rye Beach cable from that pole of the battery which was connected to the Irish sheathing, reversing when the battery was reversed. Thus, in the figure the copper pole of the battery being shown connected to the sheathing, the deflection represented a current from the copper pole entering the Rye Beach cable through the mirror.

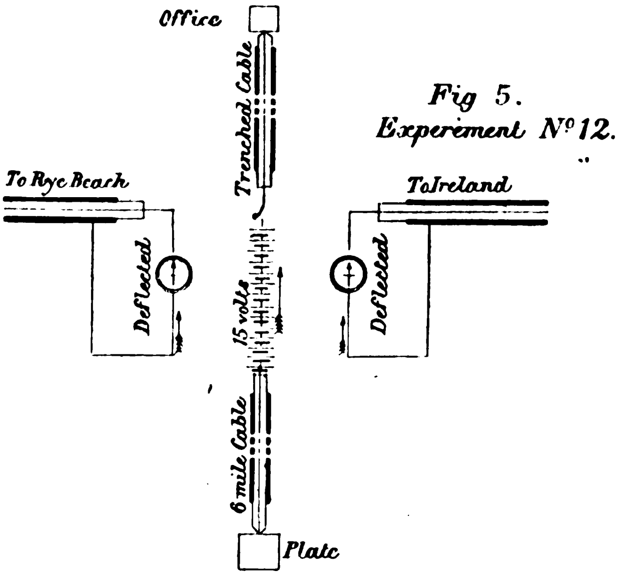
Experiment 12 (see Fig. 5).—The Irish sheathing was replaced in the battery circuit by the water-pipe earth connection at the office through the trenched cable. On depressing the key the mirror showed the same permanent degree of disturbance as before in each cable circuit.

Experiment 13.—This experiment was a repetition of No. 3, with the condenser removed. It was subsequently observed in this case that the disturbance was not permanent during the depression of the battery key, but consisted of a small vibration of the spot at the opening and the closing of the battery circuit.

Experiment 14 (see Fig. 6).—This was carried out at the office, situated in the principal street of the town and nearly opposite to the Western Union Telegraph Office, 50 yards distant. All the Western Union wires are overhead, and the earth connections made for them are the gas and water mains, which, with the telephone lines, form the only metallic connection between the two buildings. With the courteous assistance of the Western Union officials, it was arranged that at a given word by telephone several of their circuits should suddenly be operated, and again, all stopped.

When this was done the effect was distinctly visible upon a mirror in circuit with each cable, the disturbance being greater on the Rye

Fig 5.
Experiment No 12.



Beach line, the earth connections being the cable sheathings through the insulated cables in the trench. Only four known causes could under any conditions produce interference between the two cable circuits, these being, of course, electrostatic induction, electro-magnetic induction, leakage, or bad earth connection in common, and in the absence of evidence, any one or more might produce it, although no reason could be demanded for the operation of any, since cables lie in other parts of the world for greater distances at equal proximity without the least visible interference.

Experiment No. 10, together with the preliminary trials with the trenched cables, showed that the causes were not to be traced locally to these or to the apparatus, and the high insulation of the cables and circuits, together with the fact that the tests were carried out at the cable-house, precluded all possibility of leakage being concerned, so

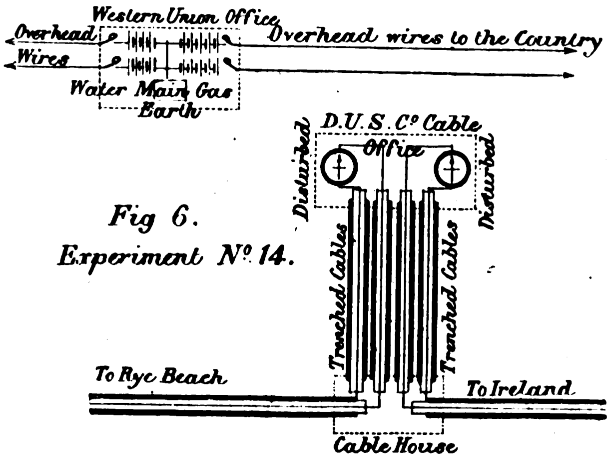


Fig 6.
Experiment No 14.

that the operating causes were thus limited to the two forms of induction and bad earth.

The first six experiments did not directly point in favour of any particular cause, but Nos. 7 and 8 rendered the possibility of electro-magnetic disturbance untenable, since the exciting circuit, except in the cable sheathing itself, took a course, as seen on the map, almost at right angles to the two main cables. They further showed that the interference was such as a deficient earth connection would produce. Experiment No. 9 confirmed this view, since no form of induction could set up the steady deflections observed; and leakage being out of the question, bad earth was the only cause that could produce them. It was further necessary to suppose that not only one but both cable sheathings failed to secure good earth, and that the resistance in their respective earth connections was common to both.

Experiment 11 corroborated this position; and No. 12 did more, for it extended the limits of this bad earth region over the whole water-pipe area of Halifax, as it would have been impossible to obtain interference under those conditions unless the cable sheathings and the town water-pipes formed a common conducting system throughout whose limits imperfect earth connection existed. Finally, the

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evidence of Experiment 14 followed the same direction, the exciting circuit being in this case the Western Union land lines.

The imputation of bad earth to the gas and water pipe area of a town, and that town a seaport, is sufficiently remarkable; but the presumption of a general earth imperfection in a system of extended water and gas mains, together with the sheathings of three cables running directly into an arm of the sea, may at first sight appear an outrage upon credulity. Due consideration of the experimental evidence renders the conclusion, however, inevitable; and this is tantamount to the assertion that the whole of this system—that is to say, all the land covered by the town, as well as that forming the harbour basin—is composed of substance more or less insulated or insulating.

One of the most interesting features in the geology of Nova Scotia is that the Atlantic seaboard presents an uninterrupted line of Lower Cambrian formation. The relation of this fact to our immediate subject is patent when we remember that these rocks—early in order of geological structure, and said to be almost destitute of organic remains—are here almost entirely composed of argillites, quartzites, and micaceous schists—slates and grits—substances experimentally known to be non-conductors; and according to the published papers of Prof. Honeyman, who has studied the geology of Nova Scotia for many years, no other formations mingle with the Lower Cambrian in the structure of the Halifax basin except the still lower archæan granites, all of which are presumably non-conductors. In fact, the renowned natural advantages of Halifax Harbour are due to the unrelieved presence of these abrupt slaty cliffs that immediately underlie the soil for miles inland.

The question then arises, granting that on the above geological considerations the rocky basin of the harbour and foundation of the city form an insulating crust, or one, at least, interposing a decided amount of resistance between the superficial conducting system and the ocean or earth's mass, is the resistance that can be jointly offered by the three cable sheathings and the whole waterway between the cable-house and open sea of sufficient magnitude to produce the degree of interference observed?

The answer, which seems to be affirmative, strictly demands a computation of the resistance offered by the entire mass of sea-water in the harbour under those conditions. This would be a gigantic problem to solve with any pretence to accordance with nature; but for the purposes of the case such limitations may be admitted as shall greatly simplify the calculation.

The map shows that three channels open upon the inner harbour, one running inland through the narrows, and two passing seawards—the eastern passage, and the main or southern entrance. The inland channel terminates in a bay some miles beyond, and may be considered to be practically insulated with the rest of the basin. The waterway in the shallow and narrow eastern passage will evidently offer a comparatively high resistance compared with that of the main entrance, which, therefore, demands principal attention.

The general mathematical theory of the earth's resistance is given in Schwendler's "Testing Instructions," following the reasoning of Smaasen's theory, published in 1847. It is shown that if a perfectly conducting small spherical electrode of radius r were situated concentrically within a larger hollow perfectly conducting sphere of radius R, and the intervening space filled with a homogeneous substance of specific resistance ρ, the resistance of any elementary spherical shell of radius x, measured from the common centre, would be $\frac{\rho\, dx}{4\pi x^2}$, and hence the total resistance (ω) between the two spherical electrodes would be the integral of this quantity between the limit $x = R$ and $x = r$; whence

$$\omega = \frac{\rho}{4\pi}\left(\frac{1}{r} - \frac{1}{R}\right).$$

If the radius R of the outer electrode be indefinitely increased, the resulting equation becomes

$$\omega = \frac{\rho}{4\pi r},$$

which represents the resistance of an unlimited medium of resistance ρ to a current passing from a sphere of radius r to its ultimate confines. Similarly, a second small spherical electrode of radius r_1 would offer under the same circumstances a resistance

$$\omega_1 = \frac{\rho}{4\pi r_1}$$

and if these two small spherical electrodes were placed so far apart in the medium that their direct influence on each other's lines of current-flow would be very small, the resistance between them would be

$$\omega + \omega_1 = \frac{\rho}{4\pi}\left(\frac{1}{r} + \frac{1}{r_1}\right)$$

—a result equivalent to the statement that almost all the lines of current-flow issuing from the surface of each electrode would unite with least opposition at indefinitely great distances, and after indefinite diffusion throughout the medium.

If the system were then symmetrically divided by an unlimited insulating plane, the resistance (Ω) between the hemispheres on one side of the plane would be double the above, or

$$\Omega = \rho\left(\frac{1}{c} + \frac{1}{c_1}\right),$$

where c and c_1 are the circumferences of the two hemispheres.

This would then be the resistance between two hemispherical electrodes imbedded in the bounding plane surface of an indefinitely extending homogeneous medium; and if the electrodes were not hemispheres, but vertical plates imbedding active surfaces (s and s_1), the above formula would approximately apply, if c and c_1 be the circumferences of equivalent hemispheres exposing those areas respectively, and the transformed equation would be

$$\Omega = \frac{\rho}{\sqrt{2\pi}}\left(\frac{1}{\sqrt{s}} + \frac{1}{\sqrt{s_1}}\right)$$

—an equation independent of the distance between the plates.

Similar results are obtained and published by MM. Mascart and Joubert by separate reasoning. The formula applies to the earth's resistance in a telegraphic circuit, on the assumption that our planet has a practical uniform conductivity, and forms practically an indefinitely extended medium.

In the absence of experimental evidence it would be difficult to say how far the variable conductivity of the earth's mass would affect the application of this formula. The conductivity of the material composing the earth's crust probably varies considerably in different localities, and is generally not the same as that of the ocean, for example. It might even be assumed that the resistance of the primary rocks is so great as to limit the conducting area almost entirely to the superincumbent stratified formations.

In that case the earth's telegraphic resistance would be more nearly comparable to the resistance between two small distant electrodes imbedded in the surface of an indefinitely extended sheet of uniform thickness and conductivity. On this supposition, let d be the depth of the earth's conducting crust, assumed to be uniform, then the resistance, Ω (*vide* appendix), between two earth-plates of active surfaces (s and s_1) would be, approximately,

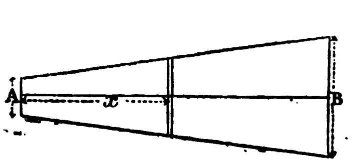
$$\Omega = \frac{\rho}{\sqrt{2\pi}}\left(\frac{1}{\sqrt{s}} + \frac{1}{\sqrt{s_1}}\right) + \frac{\rho}{\pi d}\log._\epsilon\left(\frac{4\,D}{d}\right).$$

This equation is the same as that of Schwendler last stated, but with the addition of a second term involving D, the distance between the plates; so that on this theory the earth's resistance would increase with the length of the circuit. If submarine cables were sufficiently well insulated, it would be possible to ascertain which of these two theories is nearer to the truth, by measuring the conductor resistances of cables which are laid in duplicate or triplicate between two stations; the difference between the resistance of any pair looped, and the sum of their separate resistances employing the earth circuit, giving, of course, double the earth's resistance between the terminals. It is, however, impossible to decide from present experimental evidence in this way, since not only does the difficulty of accurately measuring these quantities probably increase with the square of the length of cable, owing to leakage and other causes, but also because this second term of the last equation whose existence is in question must in all cases be very small.

Generally speaking, therefore, the experimental evidence may be said to establish the results given by Schwendler's formula—namely, that when the earth-plates are separated by any distance great compared with their dimensions, the resistance varies with their active area, and is independent of their distance.

Schwendler gives an estimated superior limit of the specific resistance of the earth in India as 3,300 ω, or about 100 times that of saturated zinc sulphate solution at 10deg. C.

Returning to the resistance offered by the waterway in the main entrance of Halifax Harbour, we may suppose a current to be flowing seawards through it, and the cable sheathings from the cable-house. The lines of flow will permeate its whole area, and the equipotential surfaces may be supposed to form across it in successive curves. These surfaces will be practically vertical, and a position has to be assumed for the ultimate one representing the zero-potential, or the surface that may be considered to mark the limit of perfect earth connection. Theoretically, of course, this limit would be far out in the ocean; but it may be arbitrarily assumed that a vertical plane, shown on the map by a dotted line, connecting the Thrumcap with the Mars Rock buoy represents this boundary, and that the resistance to earth of the ocean mass outside this plane is altogether negligible. The two other dotted lines converging from this base up to the cable-house—one skirting Sandwich Point, and the other running over Maugher Beach—are intended to represent what may be considered the simple boundaries of an equivalent waterway equal in conductivity to the actual one. The average depth may be taken as 14 fathoms. We have, on this supposition, a mass of sea-water resembling a wedge with a blunt point, the breadth of the base being 1·2 knots; the breadth at the apex, say 5 metres; the length measured perpendicularly to the base, 4 knots; and the depth, 14 fathoms. Strictly speaking, the equipotential surfaces of flow will be curves convex to the ocean; but the error introduced will not be great if we consider them as planes parallel to the base, or zero surface. Since the fall of potential will take place with equal rapidity through the water and through the sheathings, the resistance of the latter may be taken into account later and independently. The



resistance of any elementary lamina of thickness dx, distant x from the cable-house, will be $\frac{\rho\, dx}{h\,(ax + b)}$, where ρ is the specific resistance of the water, h the depth, while a and b are constants; so that the tota resistance between the two ends is

$$R = \frac{\rho}{ah}\log._\epsilon\frac{B}{A},$$

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where B and A are the breadths at the base and apex. In this case

$$a=\frac{1\cdot 2}{4\cdot 0}=0\cdot 3\ ;$$

$$h=14\times 6\times 30\cdot 5=2{,}560\ ;$$

$$\frac{B}{A}=\frac{185{,}000\times 4\cdot 2}{500}=1{,}550\ ;$$

$$\rho=31.$$

The specific resistance of a saline solution of density 1·027 has been observed experimentally to be about 31 ω at 5deg. C.

With these data,

$$R=\frac{31\times 2\cdot 72\times 3\cdot 19}{0\cdot 3\times 2{,}560}$$

$$=0\cdot 35\ \omega,$$

about one-third of an ohm, equivalent to a conductivity of .... 2·9 mhos.

Compared with this, the conductivity of the eastern passage channel may be estimated at about one-fourth, or .... 0·7 mho.

The conductivity of the two cable sheathings, each consisting of 10 No. 6 wires, and length 4·2 knots, would be 20 × 0·020 .... = 0·4 mho.

And, finally, the conductivity of 7 knots of cable sheathing in the eastern passage, 10 × 0 012............ = 0·1 mho.

Total conductivity .... 4·1 mhos,

equivalent to a joint resistance of 0·24 ω. So that if the above reckoning is sufficiently fair, the resistance between the cable-house and the ocean is about a quarter of an ohm.

The resistance actually offered can be estimated from the data of Experiment 11, as follows:

The E.M.F. in the exciting circuit was about 15 volts ; the resistance, 66 ω in the cable and earths, and 24 in the battery—total, 90 ω. In the Rye Beach circuit the resistances at the time were, approximately :

Observing mirror............	2,000 ω
Cable conductor	5,800
Relay at Rye Beach............	1,000
Total............	8,800 ω

Since the interference current observed in this circuit was, as already mentioned, 5×10^{-6} amperes, the E.M.F. impressed upon the cable due to interference was

$$5\times 10^{-6}\times 8\cdot 8\times 10^{3}=0\cdot 044 \text{ volts ;}$$

and consequently, if x be the required resistance of the general earth connection,

$$x:90::0\cdot 044:15,$$

or $$x=0\cdot 26\ \omega,$$

or an actual resistance of a quarter of an ohm. The agreement between the actual and measured values is really much closer than the accuracy of either determination would warrant.

The only experimental results still left unaccounted for are those of Nos. 3, 4, 5, and 6, in all of which the six-mile earth was used either in the exciting or observing circuit ; and since Experiment 13 proved that this earth-plate was outside the limits of the semi-insulated basin, as might be expected from its position on the map, it would be impossible to account for the interference in those cases on the score of a common imperfect earth. Reflection shows, however, that the interference observed would be an indirect necessary consequence of the imperfect earth, since the six-mile earth, when connected to either main circuit, forms a cable-loop of, say, 10 knots within the limits of the semi-insulated basin, and a slight variation in the potential of the basin is calculated to produce a considerable electrostatic effect on the cable. It has, in fact, been found experimentally that when 1,000ft. of insulated cable core (of similar capacity to that of the cables at Halifax) are coiled in an insulated tank and left in communication with the earth through a mirror instrument, the electrostatic disturbance of the mirror is about equal to that observed in these experiments (3—6) when the potential of the tank is altered by 0·2 volt. The total charge passing through the mirror in Experiments 3 and 6 would be the resultant effect of the whole system of harbour potential variation on the four knots of cable under observation, except in so far as the capacity of the cable seawards would modify the influence. In Experiments 4 and 5 the interference would, on the other hand, be due to electrostatic charge entering the observing circuit owing to the variation in the harbour potential, electrostatically produced by the loop of exciting cable traversing it. An external average variation of 0·01 volt in the potential of the basin would suffice to account for the degree of interference observed ; and this amount of variation, it is evident, the conditions amply supply. Experiment 13, contrasted with Nos. 9 and 11, showed that the interference observed in cases 3, 4, 5, and 6 was of an electrostatic nature.

The sensitiveness of a cable to external electrostatic influence can be shown experimentally by joining up a mirror galvanometer in circuit with 100 miles of cable and earth. If the distant end be sealed, and laid for two or three feet in an insulated joint trough filled with water, the potential of which is capable of being varied suddenly through 100 volts (from +50 to −50), the effect is immediately visible on the galvanometer ; and, in fact, simple signals have been transmitted in this way from ship to shore through the coatings of a joint.

The hypothesis of an insulated or semi-insulated basin, therefore, satisfactorily explains all the phenomena observed. It accounts, first, for the meteorological disturbances which are observed on the cables, since any alteration of the charge or position of electrified clouds in the vicinity of the harbour may affect the distribution of charge in the cable to an extent that would not be possible if the harbour were in more perfect electrical communication with the ocean or earth's mass ; and all the phenomena experimentally observed can be traced either to the direct or indirect effects of this imperfect earth connection—directly by conduction, indirectly by induction.

Assuming, then, that the Lower Cambrian rocks effectively insulate the Halifax basin, it is necessary to suppose that the same effect would be produced at any landing-place on the Atlantic shore of Nova Scotia, where these rocks so generally prevail. This is also corroborated by the fact that previously, at Torbay, some difficulty of the same kind appeared when attempts were originally made to utilise an ordinary earth connection for an overhead Morse circuit. The interference with the cables thus set up rendered a special earth necessary for the land line in the bay. The fact that no interference was visible between the cables themselves is accounted for by the open landing-place and absence of any such basin as Halifax Harbour presents.

In Mr. James Graves's paper on earth vibrations, already alluded to, mention is made of the slaty character of the rock in the neighbourhood of the station, and so favours the supposition that the interference there observed was due to the same causes.

It is said that in the Lake Superior region of the United States great difficulty has occasionally been found in obtaining efficient earth, even when no local cause for the deficiency has been apparent. I am indebted to Prof. Moses G. Farmer for the facts of a case which came under his notice, where an earth connection, apparently good and well situated, was found useless, and measurement showed that its resistance to earth was 12,000ω. I also owe to him the information that interference due to imperfect earth was found in 1869 at St. Pierre Miquelon, the Morse signals on the St. Pierre Placentia circuit affecting the Atlantic cable to Brest, and that special measures had to be taken to effect better earth connection.

Generalising from these facts, it would seem that there may be difficulty in obtaining good earth at cable stations opened on a shore of primary or metamorphic rock, and that permanent interference beyond remedy by earth connection is possible between cables landed in a basin of such formation ; so that if this statement receive confirmation at the hands of the members of this Institution it will be evident that a due regard will be given to geological conditions by electrical engineers among the many incidental considerations that determine their selection of a cable's landing place.

Appendix.

On the resistance between two electrodes of active surface (s and s_1) imbedded in the surface of an indefinitely extended homogeneous medium of specific resistance ρ comprised between two unlimited parallel planes separated by a perpendicular distance d, the distance between the electrodes being represented by D.

Let r and r_1 be the radii of the equivalent hemispheres exposing surfaces of s and s_1 respectively. Then, if an infinitely thin perfectly conducting hemispherical shell of radius d concentrically surrounds each of these electrodes, these shells will touch the opposite bounding plane of the medium, and the resistance between them and their included electrodes will be

$$\frac{\rho}{2\pi}\left(\frac{1}{r}-\frac{1}{d}\right) \text{ and } \frac{\rho}{2\pi}\left(\frac{1}{r_1}-\frac{1}{d}\right) \text{ respectively.}$$

If D be large compared with d, these two shells may be approximately considered as two parallel cylinders of radius $\frac{d}{2}$ traversing the medium at right angles to the bounding planes, and their surface potentials may be written (see Mascart and Joubert's "Electricity and Magnetism," vol. i., p. 205)—

$$V_1=\text{constant}-\frac{c\rho}{2\pi d}\log.\epsilon\left(\frac{\frac{d}{2}}{D}\right);$$

$$V_2=\text{constant}-\frac{c\rho}{2\pi d}\log.\epsilon\left(\frac{D}{\frac{d}{2}}\right),$$

where V_1 and V_2 are the potentials and c the strength of current.

$$\therefore V_1-V_2=\frac{c}{2\pi d}\left(\log.\frac{2D}{d}-\log.\frac{d}{2D}\right),$$

$$\therefore \text{Resistance}=\frac{\rho}{\pi d}\log.\epsilon\left(\frac{4D}{d}\right);$$

so that the total resistance,

$$\Omega=\frac{\rho}{2\pi}\left(\frac{1}{r}+\frac{1}{r_1}-\frac{2}{d}\right)+\frac{\rho}{\pi d}\log.\epsilon\left(\frac{4D}{d}\right);$$

and since d is large,

$$\Omega=\frac{\rho}{\sqrt{2\pi}}\left(\frac{1}{\sqrt{s}}+\frac{1}{\sqrt{s_1}}\right)+\frac{\rho}{\pi d}\log.\epsilon\left(\frac{4D}{d}\right),$$

approximately.

Papers.—At the Institution of Electrical Engineers next Thursday, Prof. Forbes "On Some Electric Lighting Central Stations in Europe and their Lessons." At the Physical Society to-morrow, at 3 p.m., in the Lecture-room, Science and Art Department, Prof. Ayrton "On Notes on Electrical Measuring Instruments," exhibiting his new instrument.

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BOUND VOLUMES.

Vols. I. and II., new series, of "The Electrical Engineer" *are now ready, and can be had bound in blue cloth, gilt lettered, price 8s. 6d. Subscribers can have their own copies bound for 2s. 6d., or covers for binding can be obtained, price 2s.*

NOTICE.

During the course of the past year we issued steel engraved portraits of Mr. E. Graves, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. Wollaston, M.D., F.R.S., *and* Sir Humphry Davy, F.R.S. *The portraits of* Prof. D. E. Hughes, F.R.S., *and of* Dr. J. Hopkinson, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

WINNING AND LOSING.

The result of litigation generally ends in the jubilation of one side, and a corresponding sorrowing of the other. It is seldom that we can write as we did of the original judgment in the Edison-Swan *v.* Holland case, "Honours divided," and perhaps it is as well that it should be so. Neither side was satisfied with a half win. Elsewhere we give the full text of the judgment in the appeal, and in this judgment the three judges engaged concurred. There is little hope that the litigation is ended, and the last information about it is that already notice has been given that it is to be carried to the House of Lords. Then, and not till then, it is to be feared, will the parties stop, and not even then—but they cannot go farther.

Nothing that we can say will influence the parties in this suit, for whoever heard of litigants accepting advice tendered by unbiassed outsiders—onlookers who have nothing to gain and nothing to lose whatever the result may be. Pity 'tis 'tis true. During the "eighties," electrical industries have advanced by leaps and bounds, but what about litigation upon electrical matters? Money has been lost and won in electrical speculations; but how about "dividends" paid to shareholders? The legal profession is a glorious profession, and we are inclined to think that the money paid to that profession, divergent from the shareholders' pockets, is out of all proportion to that which has gone into the shareholders' pockets. This golden stream seems likely to be so diverged till the mass of patents taken out during the last ten years expires by flux of time. There are many ways of looking at the question of patents, and it would take a volume to adequately discuss one half of them. Our purpose will be served by putting clearly forward the views which seem to permeate the profession, some members taking the one view, some the opposite.

The question in dispute is the validity of the Edison-Swan combination patents. It is a fact admitted by everyone that Swan and Edison were simultaneously working out the question of practical incandescent lamps at about the same time. Swan had made lamps, but they were looked upon as imperfect, as was shown by letters passing between Swan and Stearn. Edison about the same time obtained a patent for a lamp which the one side says is not practical, and has never been commercially made. The judges hold that the lamp of the patent is practical, and the validity of the patent has nothing to do with the lamp being made commercially. That improvements were to be expected directly the manufacture on a commercial scale commenced, was but natural. Such improvements were made, and the commercial lamps are the result of those improvements. Given the original

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more or less crude but practical idea, and hundreds of minds turned at once to its study, producing a crop of patented improvements, and which the patentees expect the law courts to proclaim valid patents. The law courts refuse to do anything of the kind, and say in effect, None of these recent improvements are inventions to be covered by a patent, and the patentees would never, without the aid of the master idea in the master patent, have invented anything of the kind. "It is easy when you know the way." It is easy to improve somebody else's invention, but it is difficult to invent. That is, in reality, the crux. As will be inferred from our remarks above, the strongest objection against the validity of the Edison-Swan patents is in the direction tending to show they are improvements of prior inventions, and not new inventions. The judges have not been convinced that this is so—hence their decision, which says, though not in so many words, that Edison did really invent the practical filament. We take it that for the moment nothing more is to be said. An official of the Great Western Railway once remarked to a person that was complaining, "The best you can do is to grin and bear it." The advice is sound in many cases, and applies to further action *re* the House of Lords. Had this appeal gone otherwise, there would have been legitimate doubt as to the result of further action. Now we feel convinced there can be none. Time after time the Edison-Swan combination has been successful, and depend upon it that fact will have considerably more weight than that they were once only partly successful. We know that these views are not held by many who have carefully considered the matter, and whose opinions are generally to be received with the greatest respect.

There is another grievance real enough from one point of view, yet it must be considered as purely sentimental. It refers to the great benefits that would accrue to the industry generally if there were no monopoly. No doubt the benefits that would accrue are, as we say, real enough, but there would have been no industry if there had been no invention—that is, if there had been no monopoly. It is better to have an industry with a monopoly rather than no industry and no monopoly. Is it impossible for the litigants to shake hands? Suppose the Edison-Swan combination feel certain of the final result, will it not pay better in the long run to amicably arrange for royalties and pay half the costs up to the present time, than to continue to take money from the industry that might be used with great advantage and put it into the pockets of lawyers, where it will give no benefit to the electrical industry? The difficulty is to stop at any stage in legal proceedings after they have once commenced, and which ought never to have commenced. At least fifty thousand pounds have been diverted from shareholders' capital to legal expenditure—an amount preposterously large in comparison to the benefit received, whatever the final result may be.

CORRESPONDENCE.

ELECTRIC LIGHTING OF HARROW.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—Mr. Crompton, last night, in the statements which he promulgated to a meeting of the Local Board and ratepayers of Harrow, will doubtless have much astonished those who either heard or read his paper delivered at the Institution of Electrical Engineers last year, and his reply to Mr. Kapp's paper, read before the same body. Mr. Crompton now poses as the advocate of a transformer system, and he now admits that the figures for which he was so much taken to task less than a year ago are entirely wrong. Mr. Crompton, after having stated that a small installation costs more in proportion than a large one of similar nature, proceeded to inform his hearers that an installation of 3,000 lights would cost but £6,000, with 1,500 yards of main, of which 1,000 were underground; and upon exception being taken to his figures, he stated that the conditions of laying mains in London, as provided for in his former paper, are quite different to the laying of mains in the country. Now, excluding the cost of mains entirely from Mr. Crompton's estimate, and that of buildings, which are necessarily more expensive in London, the following will be found a correct statement of the figures of yesterday and of last year.

For a 3,000-light plant, Mr. Crompton made out figures as follows at the meeting held yesterday:

Engines	£1,560
Dynamos	1,800
Switchboard and measuring instruments...	100
Transformers	850
	£4,310

Last year, Mr. Crompton estimated the cost of a 10,000 light or 600 kilowatt plant at:

Dynamos and exciters 865 kilowatts, including spare sets, divided as convenient	£5,540
Motive power—*i.e.*, engines, boilers, steam and feed connections, belts, etc.—at £8. 12s. per h.p.	12,470
500 transformers—*i.e.*, one of every pair of houses at £15 each	7,500
Regulating gear	500
	£26,010

that is to say, taking in round numbers the 10,000-light plant at £26,000 and the 3,000-light plant at £4,300, the former plant at the same price as the latter would only cost about £14,400, or, say, 60 per cent. of the cost, as estimated in Mr. Crompton's paper before the Society of Telegraph Engineers. As Mr. Crompton's figures will, we feel sure, give much encouragement to the transformer party (among whom we beg to subscribe ourselves), we do not care to criticise them for fear of scaring such an influential convert. It will be recollected that Mr. Crompton, in his reply to Messrs. Kapp and Mackenzie last year, made mention of the waste which occurred by running triple expansion engines with alternating current dynamos and transformers on light loads, which were absolutely necessary at full load to reach the highest peak of any ordinary load diagram. Mr. Crompton, in reply to a query last night, said there was a difference, in that in the Harrow schoolhouses the peak would be a plateau. Mr. Crompton did not seem to acknowledge the fact that a simultaneous lighting of 2,500 lamps at 6.45, when the boys come in from school, would have exactly the same effect as a peak, and the similarly simultaneous extinction of the lamps later in the evening would give a diagram rather like a factory chimney, and, according to Mr. Crompton's old theory, be even more wasteful in the hours of lightest load than the gradually ascending and descending peaks of a London diagram.

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It seems to us that the whole blame attaching to Mr. Crompton's fiasco lies with Mr. Hayward, who, as will be seen from the report of the meeting, either wilfully or unintentionally forgot the fact of the appointment of a special committee on the subject, a matter with which, as chairman of the Board, and present when the committee was appointed, he ought to have been perfectly acquainted. We reserve our further remarks to another issue of your journal.—Yours, etc., W. F. AND F. TAYLOR.

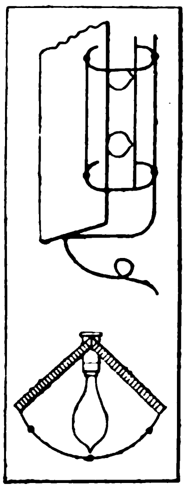
Harrow, February 20, 1889.

[As a full report of the meeting is given elsewhere in our columns, our readers will be able to form their own conclusions upon the questions above mentioned.—ED. *E. E.*]

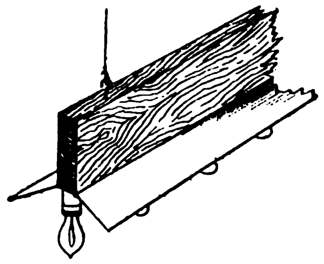
ELECTRIC LIGHTING OF THEATRES.—IV.

AVENUE THEATRE.

The installation at the Avenue Theatre, Northumberland-avenue, is one of the most recent, and, as might be expected, one of the most conveniently arranged in London. This theatre is one of those drawing its supply of current from an outside source, connection in this case having been made, by means of underground mains in bitumen troughing, along Whitehall-place, to the Metropolitan Electric Supply Company's station at Whitehall Court, where the low-tension direct current system is in force. The interior arrangements have been carried out by Messrs. B. Verity and Sons, Covent Garden, and they have produced a very compact, convenient, and satisfactory theatre installation.



Side Lights.



Battens.

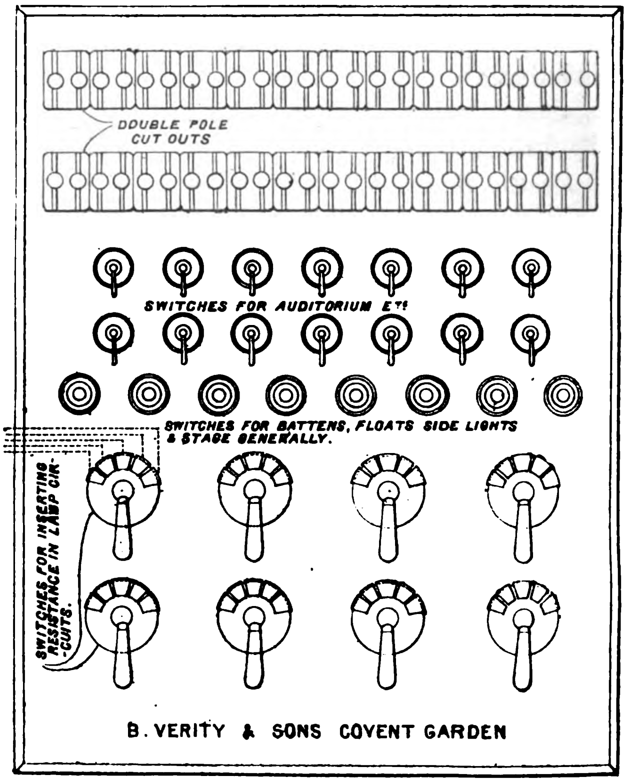
The whole of the theatre is now lighted electrically, both before and behind the scenes and in all the dressing-rooms and passages, the sunlight alone in the centre of the auditorium being excepted; here gas is still used for centre light and for purposes of ventilation. The following is a list of the lamps installed, which will serve to give a very good idea of the distribution of light necessary in a theatre:

Stage.—Battens, 200, in four sets; footlights, 50; proscenium, 30, in two sets; sidelights, 86; doors to stage, 2—total for stage, 368.

Auditorium.—Stalls entrances, 3; stalls, 4; pit, 5; pit entrance, 4; gallery, 18, gallery entrance and staircase, 7; dress circle, 10; box office and main entrance, 11; front staircase, 15; private office 3.

Basement.—Corridors and stairs to stage, 11; dressing-rooms, prompt side, 14; dressing-rooms, O.P., 14; dressing-rooms and passages under stage, 14—total in front of stage, 123. Total number of lamps, 491.

The lamps are all Edison-Swan lamps of 16 c.p., mounted mostly in Edison sockets. All the stage lamps are arranged to be raised or lowered in brilliancy for scenic effects. The battens—the rows of lights which swing across the top of the stage to illuminate the scenes—are arranged on swinging boards, which can be very easily raised or lowered in height by the scene-shifter, by means of cords and pulleys. The method adopted for these is neat and simple. A long plank is suspended edgewise, and a series of lamp sockets are screwed to the lower edge of this plank, allowing the lamps when fitted to hang down with unimpeded light. Each batten has a long broad strip of bright tin plate fastened to it at the back of the sockets, and this forms a cheap and very efficient reflector, giving a greatly increased light from the lamps upon the scenes. The sidelights are also arranged to be movable, and are mounted on a long frame made of two pieces of wood joined at right angles, and mounted with a series of lamp sockets. Stout wire protectors are fixed all the way down on each of these to prevent the lamps being knocked accidentally, and each set of sidelights is furnished with a flexible cable, ending in a floor-plug as illustrated, which can immediately be inserted into a hole in the stage floor behind the scenes to make electrical connection. These sidelights are hung upon suitable pegs at the side of the stage, and both these and the battens can be far more easily shifted than the rows of gas-jets hitherto used.



Switchboard at the Avenue Theatre.

The switchboard is very conveniently arranged beside the prompter's box, just inside the side scene. The whole of the switches for the theatre are brought to this one switchboard, and the management of the light is under control from this point. The so-called "gasman" can stand at the prompter's box in full view of the scenery, and can from this position, within reach of his hand, turn in and out, or raise and lower, any of the lights of the theatre. The arrangement of this switchboard is seen in the accompanying diagram. Large switches with multiple contact are arranged for those lights requiring to be varied in brilliancy, and these are connected with an iron wire resistance, which is arranged in a frame on the passage wall immediately below the switchboard. Two rows of Verity's small sudden-break lever switches, with a row of larger switches of a similar kind below as shown, are used to control the various circuits of the auditorium. Double pole fuses of the Edison screw socket type are used, and the whole of these, to control all the branches, are fixed in two rows, as shown on the switchboard above the switches.

Solid double pole main fuses are placed alongside the switchboard to control the main circuit. The fusible metal for these is a special alloy obtained from New York. The mains coming from the street are Callender's cable. The interior mains, branches, and wires are of Henley's manufacture throughout. The fittings are simple, tasteful, and decorative, all made by Messrs. B. Verity and

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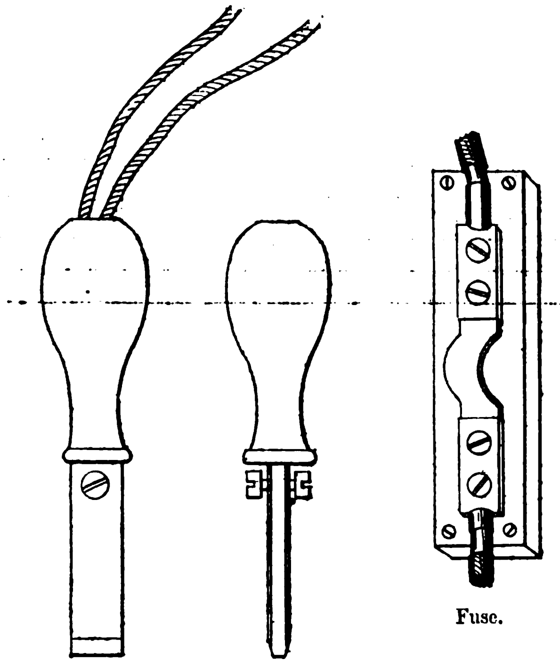
Sons. The installation as a whole is thoroughly satisfactory, so much so that the managers made Messrs. Verity a present of a bonus of £20 over the contract on the completion of the installation, a circumstance which is a



Fuse.

Stage Plug

little unusual, and which we have the greatest pleasure to record.

ADVANTAGES.

We had some conversation with the manager, Mr. H. Watkin, upon the question of the adaptation of the light for theatres and its general advantages. He regards the light as admirably suited to the purposes of a theatre. It is clean, extremely convenient, and perfectly under control; they have a sensible reduction in the insurance; the cost of supply is less than that of gas, and the breakages of the lamps bring it to about the same amount.

The actors speak very favourably of the difference of temperature perceptible upon the stage. They often used to come down to the dressing-room bathed in perspiration from the heat of the footlights, and now are as cool and comfortable as possible.

ALTERNATE CURRENT MACHINERY.*

BY GISBERT KAPP, A.M.I.C.E.

The theory of alternate-current machines, as given in modern text-books, was based upon the assumption that the currents were generated in wire coils, the magnetic induction through which underwent periodical changes according to a simple sine function. A machine of this character would be represented, in its most elementary form, by a coil of insulated wire revolving round an axis in its own plane, with uniform velocity in a uniform magnetic field, the axis of rotation being at right angles to the lines of the field. The E.M.F. at any moment was

$$e = 2 \pi n z \frac{\tau}{2} \sin \alpha,$$

where n was the frequency (number of complete periods per second), τ was the number of wires in both branches A and B of the coil collectively, z was the total induction through the coil when the latter stood at right angles to the lines of force, and α was the angle between this position and the position at which the E.M.F., e, was generated. The mean E.M.F. was

$$e = \frac{\pi}{\sqrt{2}} n z \tau.$$

It was convenient to compare this value with that representing the E.M.F. of a direct-current machine having the same field and external number of wires, τ (but equally distributed) on the armature. The E.M.F. of such a machine was given by the product $z \tau \frac{N}{60}$, where N, the number of revolutions per minute, might obviously be replaced by $60n$ when the machine had two poles, because in this case frequency and number of revolutions per second were identical. The ratio between the E.M.F.'s of the two machines remained the same, $\frac{\pi}{\sqrt{2}}$.

Alternators as now constructed had more than one pair of poles, which were set in a circle, and were so arranged that the coils of the armature swept past them. As the interpolar space was always very small, the density of lines, emerging from or entering the polar-surfaces, might be taken as fairly uniform over the extent of these surfaces, and it became thus possible to determine for every shape of coil the configuration of polar surface which would produce that variation in the induction which corresponded to the simple sine function. Poles of this shape were, however, not used in practice; the poles were either trapezoidal, circular, or rectangular. In the Mordey alternator the poles had a trapezoidal face, and those succeeding each other on the same side of the armature were of the same sign, and were placed in line with those of opposite sign on the other side of the armature. Thus along the mean pitch-line, uniform fields alternated with spaces in which there was no induction. The E.M.F. of this arrangement was

$$e = 2 n z \tau.$$

The type of field most commonly used in modern alternators was, however, one in which N and S poles succeeded each other around the armature, and the portion of the armature not embraced by the poles might be taken as equal to that embraced. The E.M.F. of this arrangement was $$e = \frac{4}{\sqrt{2}} n z \tau$$

These results referred to machines in which the active wires on the armature were concentrated into single lines. This was, of course, impossible in practice; the wire coils on the armature, whether this contained iron or not, must occupy a considerable space, and this circumstance would, generally speaking, cause the E.M.F. obtainable, with the different forms of fields considered, to be lower than the values given. The reason for this reduction was that with a wide coil all the turns were not equally and simultaneously influenced by the field, and in certain positions the action was differential. The calculation of the effective mean E.M.F. for the configuration of field and armature-coils presented no special difficulty, though for certain complicated forms the operation was somewhat laborious.

The E.M.F. of an alternator could be expressed as the product of the E.M.F. of a direct-current machine, having the same dimensions and weight, and a certain coefficient depending on the configuration of the field-magnets and armature-coils. The winding and other constructive data of an alternator being known, it was only necessary to find this coefficient, in order to determine the E.M.F., by reference to the E.M.F. which would be produced by the same machine if the armature-coils were connected in such a way as to give a continuous current. The E.M.F. in volts of an ordinary dynamo was given by the formula: $e = z \tau \mathrm{N}\, 10^{-6}$,

where z represented the total induction in English lines of force (each equal to 6,000 C.G.S. lines), τ the total number of active wires counted all round the armature, and N the speed in revolutions per minute. If the machine was multipolar, and if the different armature circuits were arranged in series, the expression for e must be multiplied by p, the number of pairs of poles in the field. Let k be the coefficient which expressed the ratio between the E.M.F.'s of the alternate and continuous-current machines, then the formula for the former was $e = k p z \tau \mathrm{N}\, 10^{-6}$.

The following table gave the value for k for different cases, all referring to poles of rectangular shape and coils in which the active wires were straight:

1. Width of poles equal to pitch, toothed armature, and winding concentrated in the recesses .... $k = 2{\cdot}000$
2. Width of poles equal to pitch, smooth armature, and winding spread over the whole surface .... $k = 1{\cdot}160$
3. Width of poles equal to pitch, smooth armature and winding covering only one-half the surface............ $k = 1{\cdot}635$
4. Width of poles equal to one-half the pitch, smooth armature and winding spread over the whole surface.. $k = 1{\cdot}635$
5. Width of poles equal to half the pitch, smooth armature and winding covering only one-half the surface... $k = 2{\cdot}300$
6. Width of poles equal to one-third the pitch, smooth armature and winding covering only one-third of the surface .... $k = 2{\cdot}830$

According to the ordinary sine formula the coefficient was $k = 2{\cdot}220$; and this agreed fairly well with case 5, which was most frequently met with in practice. The formula for e pre-supposed the knowledge of the total induction, z, which depended upon the shape and size of the field-magnets, their arrangement, the amount of iron in the armature, the interpolar space, and the exciting power. This subject had been very fully treated by Drs. J. and E. Hopkinson, and the author had also dealt with it. These methods had subsequently been improved by the introduction of certain terms due to Prof. Forbes, by means of which the magnetic leakage could be more accurately ascertained. With the knowledge of the total induction, z, and the coefficient, k, it was thus possible to determine the relation between exciting power and E.M.F. of any given alternator. The effect of self-induction was to produce an E.M.F., the phase of which was at right angles to that of the current; and the E.M.F. available for doing work in the circuit was the resultant of the induced E.M.F. and that due to self-induction. The author then described some graphic methods by which the problem could be treated in a simple and easily understood manner.

In alternators used for parallel distribution, the object aimed at was generally to keep the terminal pressure constant for all currents, and this could be attained by working with a constant field and suitably varying the speed, or by maintaining a constant speed and adjusting the exciting current so as to suitably vary the E.M.F. The latter plan must be adopted if several machines were worked in parallel; and in this case the graphic method might be used to determine the limits between which the exciting current must be varied to keep the terminal E.M.F. constant for all loads, from no current to

* Paper read before the Institution of Civil Engineers, Feb. 19.

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the greatest current, the armature was intended to pass. The mean induced E.M.F., e, was found by the above formula, and its maximum value was obviously

$$E_1 = \sqrt{2}\,e.$$

The maximum value of the E.M.F. of self-induction was given by

$$E_s = 2\pi n L I,$$

where L was the coefficient of self-induction, which could be determined by various well-known methods; or by running the armature in a constant field, and measuring the terminal E.M.F. with and without a current passing through the armature. The E.M.F. lost in resistance was simply the product of the current, I, and the resistance, R, of the armature. With the knowledge of these quantities it was easy to determine the strength of field required for any current.

The problem of parallel working was of the greatest importance for central stations, as only by such an arrangement of machines was it possible to ensure absolute continuity of the service and the greatest economy at all times. Alternate-current distribution should, if possible, be carried on in the same simple manner as direct-current distribution—that was to say, the number of machines at work should correspond as nearly as possible to the output at any time; the addition or withdrawal of machines should not even momentarily interrupt the supply of current to any part of the system of distribution. These conditions, it would easily be seen, could only be fulfilled if the machines were capable of working in parallel, and the problem might be stated somewhat in this fashion: Given an alternator, with excited field and running at a proper speed, and a pair of terminals from which any desired strength of current could be obtained at a constant pressure, and having a frequency approximately corresponding to the speed of the alternator, what would be the condition under which the alternator would fall into step with the supply current, and what would be the relation between the current passing and the mechanical energy given off? Also, how would this relation be affected by variations in the strength of the field? This problem was also treated by graphic methods, and it was found that the only and sufficient condition, for successful parallel working, was a sensible amount of self-induction in the armature circuit. It was well known that alternators having no iron in their armatures could not be run in parallel, except by the adoption of some such expedient as choking coils; also that parallel running was feasible with those alternators which had iron-cored armatures. If a machine were run at constant speed on open circuit, and with different strengths of exciting current, different terminal E.M.F.'s were obtained. A characteristic could then be plotted, the abscissas of which represented exciting power, whilst the ordinates represented terminal E.M.F., which in this case was the same as the induced E.M.F. Having obtained this curve, which the author suggested should be called the "static characteristic," the dynamic characteristic of the machine was determined for a certain current through the armature, by so adjusting the resistance in the external circuit, that for all exciting powers the current remained the same. The curve so obtained must obviously lie wholly under the first curve, and the difference between the ordinates of the two curves depended upon the choice of current for which the second test had been made, and upon armature-resistance and self-induction. Besides these two curves there was a third—namely, that obtained when the machine was driven as a motor running light. To find this curve it would be necessary to have at disposal at least two similar machines, using the one as generator and the other as motor, and during the test the field-strength of both machines would have to be regulated, so as to keep the current at its predetermined value. Thus, a "motor-characteristic" would be obtained, lying wholly above the "static characteristic." As the last experiment was, however, only possible if two machines could be tested at the same time, and was also somewhat delicate, another method of investigation was desirable. This could be done by using one of the author's diagrams to deduct the motor-characteristic from the two other curves, the experimental determination of which presented no difficulties whatever, and would, indeed, be made as a matter of course in the ordinary test of the machine before it was sent out from the manufacturers. Diagrams were shown which contained these various curves as determined for one of the author's machines, constructed for an output of 60 kilowatts.

In any dynamo machine there were two causes for heating, in addition to purely mechanical friction. These were the resistance of the conductors, and the change of magnetisation of the iron parts of the machine. As regarded the first cause, the liability to the generations of eddy currents in the armature conductor was much greater with alternators than with continuous-current dynamos, and in alternators it varied with the construction of the armature to a greater degree. When the armature contained no iron, the heating from eddy currents was much greater than when such a core was used, and the armature conductor must therefore be made in the form of a very narrow strip. The other cause of the generation of heat—the change of magnetisation in the iron parts—could be minimised by lamination, but never entirely avoided. In direct-current machines the heating from this cause was, however, generally so small that no account was taken of it, except when the induction in the armature core was pushed beyond 18,000 or 20,000. In alternators, a much lower induction produced sensible heating, and it was for this reason that the maximum induction must be fixed at a very low figure. With a perfectly laminated core, the heating was attributed to an effect which Prof. J. A. Ewing called "hysterēsis," and which might be described as molecular friction. This scientist had experimentally determined the energy required to carry certain samples of iron through a complete cycle of magnetisation of varying degree, and the results had been published in the "Philosophical Transactions." They were given in ergs per cubic centimetre; but as these units were rather inconvenient for application in the workshop or drawing-office, the author had in the following table, which referred to annealed wrought iron, translated them into watts per ton and h.p. per ton.

Induction.	Watts per ton $n = 100$.	H.P. wasted in heat.
2,000	650	0·87
3,000	1,100	1·48
4,000	1,650	2·21
5,000	2,250	3·02
6,000	2,900	3·89
7,000	3,750	5·03
8,000	4,450	5·97
9,000	5,550	7·43
10,000	6,650	8·90

Modern transformers were provided with a core of laminated iron, which was symmetrically placed in respect to the two windings, so that the same induction passed through both the primary and the secondary coils. Under these conditions the E.M.F. induced in the two circuits was simply proportional to the number of convolutions they respectively contained, and the terminal E.M.F.'s were found by adding in the case of the primary, and subtracting in the case of the secondary, the loss of pressure due to the resistance of the coils. In a properly designed transformer, this loss of pressure should not exceed about 1 per cent. of the terminal pressure, so that the maximum difference in the pressure maintained in the secondary circuit between the lamps, when the apparatus was used for parallel distribution, did not exceed 2 per cent. between full load and no load, provided the pressure in the primary circuit was kept constant. Such a small variation in the pressure was well within the limits attainable in direct lighting, when a compound-wound dynamo was driven from an engine with a fairly good governor, and the corresponding variation in the illuminating power of the lamps was sufficiently small to be tolerated. A greater variation, especially if it occurred suddenly, would, however, not be permissible; and the question, therefore, arose as to what rules should be followed in designing transformers so that they might as nearly as possible be self-regulating. The obvious answer was, make the resistance of the circuits as small as possible, and this might be accomplished in three ways: 1. By using wire of large area. This expedient naturally increased the weight, bulk, and cost of the transformer, and must, on account of commercial reasons, not be pushed too far. 2. By employing a core approximating to a circular or quadratic section, so as to decrease the perimeter of the coils. 3. By working with a high induction, or with a high frequency. The mean E.M.F. in volts, induced in the coil of a transformer, could be expressed by the following formula:

$$e = (q)\, 2\, \pi\, n\, z\, \tau\, 10^{-8},$$

in which (q) was a coefficient denoting the ratio between the maximum and the mean E.M.F., n was the frequency, z the total induction in absolute units, and τ the number of turns contained in the coil. The larger z, and the smaller n, might be the length of wire, and therefore its resistance. On purely theoretical grounds it would thus seem that a small core strongly magnetised, and as high a frequency as the alternator could be constructed to give, would produce the best results. In practice, however, this conclusion was wrong, and the heating of the iron core in consequence of hysterēsis must be taken into consideration. Since a transformer was an apparatus at rest, and was frequently placed in a position where the cooling effect of the air was small, the ratio between heat generated and available cooling surface must be very different from that permissible in a dynamo, and it was this ratio which was the true limit to the output of a transformer. The armature of a dynamo was not subjected to excessive heating if a cooling surface of about one square inch per watt was provided. In a transformer, the amount of cooling surface should be at least three times, and if possible, four or five times as great, especially as it was somewhat difficult to determine, in a body of such complicated shape, what was and what was not effective cooling surface. From the above table it was easy to calculate for any induction, frequency and weight of the active iron in a transformer, what the heat of the iron would be; and, adding to this the heat of the copper, the total cooling surface required to keep the apparatus at a safe temperature could at least approximately be determined, or the limit of output for any given transformer could be approximately found.

The question of frequency, alluded to in connection with alternators, was also of considerable practical importance with regard to the transformers, and it was much to be desired that electrical engineers should adopt a common standard. The following was a list giving the average frequencies adopted by several designers: Ferranti, 67; Lowrie-Parker, 88; Mordey, 100; Zipernowski, 42; Kennedy, 60; Kapp, 80; Westinghouse, 133. Taking the average of European practice, the frequency was 73, or 8,750 reversals per minute, whilst the American practice was 16,000 reversals per minute. This large difference might, to a certain extent, be accounted for by the general preference of European engineers for machines running at moderate speeds; but even when making due allowance for this circumstance, it could hardly be assumed that, had actual practice shown the value of a very high frequency, electrical engineers would not have found means to obtain it. As a matter of fact, most makers of alternators had started with a much higher frequency than they had finally adopted. It should also be remembered that the higher the frequency the greater was the loss of conductivity in the mains, owing to the unequal distribution of current throughout their cross-section.

The author then discussed the questions of alternate-current motors on the Ferraris principle, and next passed on to a description of the different modern alternate-current machines most in use. Constructive data were given for the Ferranti, Mordey, Kennedy, Kapp, Lowrie-Hall, Westinghouse, and Zipernowski machines; and in most cases the actual performance of the machine was compared with the calculated E.M.F., so as to show within what limits the author's formulas for alternators of different types were in accord with experimental results.

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ELECTRIC LIGHT SCHEME FOR HARROW.

An important meeting was held at the Local Board Offices, Harrow, on Tuesday evening last, "to receive from Mr. R. E. Crompton (senior managing director of Crompton and Co.) a practical proposal on the introduction of the electric light into Harrow."

Mr. R. B. Hayward was in the chair, and there were also present: Dr. Stevens, Messrs. W. B. Walker, T. Dell, J. W. Paine, A. J. Batchelor, J. A. B. B. Bruce (members of the Lighting Committee), the Rev. F. H. Joyce, the Rev. W. D. Bushell, Messrs. A. G. Watson, G. Griffith, B P. Lascelles, J. E. Marshall, E W. Howson, W A. Hewllett, W. F. Taylor, F. Taylor, E. C. Trevor, J. L. Chapman, R. E. H. Fisher, D. Pitcairn, etc.

The **Chairman** said that before introducing Mr. Crompton he had better perhaps define the position of the Board in regard to the matter they had met to discuss. They would recollect that last autumn a public meeting was held, at which the question was discussed, and a resolution was passed requesting the Local Board to take up the matter and look into it. The Board referred it to the Lighting Committee, who inspected a very successful lighting station under the auspices of Mr. Crompton. A short time ago Mr. Crompton offered to come down and explain a scheme, and the offer being accepted this meeting was arranged.

Mr. Crompton, who was then asked to address the meeting, said he had come down there to try and extend the use of electric light. It was somewhat encouraging that this was not the only place at which he was hopeful of doing good work. He had to visit three or four other towns this week where they had seriously resolved to take the matter up. There was a great move in the direction of an increased use of electric light, more so on the Continent than in England. There was no need for him to detain them by speaking about the advantages of the electric light. All of them had seen enough of it to know that both from the point of view of health, and comfort, and convenience it was very desirable. The matter of the distribution of electricity was sufficiently perfected to enable him, as representing a firm of contracting engineers, to lay a scheme before them with confidence, for which his company would take part payment in shares, and this scheme would be as good an investment as gas and water shares had been in the immediate past. Great doubts had been cast upon electrical distribution as a remunerative investment. The cause was this. A few years ago a great many companies started which were merely speculative companies for the promotion of certain patent rights. Nearly all of them came to grief, and a large number of people consequently pulled their purse-strings tight afterwards. It was then a most uphill job to persuade anyone to invest in that form of undertaking. It took him three years to persuade people to supply the capital for the central station at Kensington, where their results had been so successful that they had found many imitators. Many large central stations were going to be started in London, and no doubt the aspect of the City next year would be widely different to what it was at present. In order to manufacture cheaply, it must be done in large quantities. Here at Harrow it was not fair to suppose that they could get an income of £2,500 or £3,000 in the first two or three years, but they would have a substantial nucleus to work upon in the shape of the school. Then, taking into account the high-class residential property, he believed a handsome profit would be yielded on the capital, if the capital was not too large. He had chosen the old waterworks as the site for the generating station, and his scheme was based on the use of that site. He had come to the conclusion that 3,000 lights could be supplied from a central station for a capital sum not exceeding £6,000, of which his company would be quite prepared to find £1,000. Mr. Crompton then explained the two well-known methods of distributing electricity—viz., the alternating transformer and the battery transformer, saying that he thought the former was best for Harrow. He proposed to use overhead wires over the piece of ground between the station, and the back of the school racquet court, from which point the mains would be underground. It was impossible that a large bid should be offered for the old water works, and he had fixed the rent at £100 a year. In the case of the underground mains, a concrete trench would have to be made, and a continuous culvert formed, of about a foot square. Underground mains had hitherto been an uncertain part of the investment in electrical plant, no one knowing how long they would last; but he took it for granted that if they eliminated all perishable material, and stuck to pure copper and porcelain, it could be maintained at 2½ or 3 per cent. on the original cost. Two or three years ago it was flung in their teeth that they knew nothing about the cost of electricity. It was untrue then, and far more untrue now. At the time he started the Kensington Company he guaranteed that the cost would not exceed £600 a year, and they had never exceeded £400 a year. He was pretty certain that the figures he was about to give them would be within the mark. If he made a mistake, it would fall on the company and not on the investors. He had supposed that £1,200 was to be obtained as revenue from the school and the houses connected with it, and it would be an extraordinary thing if another £1,200 could not be obtained from other private consumers. The cost of producing a supply sufficient for this demand would be £1,450 a year, which would include £600 for depreciation every year. The consumers would have to pay by meter. It had been said that they had no electric meter, but there were two or three which the consumers could choose from. He would give them the working costs in detail: Coal, £200; stores, £50; maintenance and clerical staff, £270; wages, £155; repairs, £150; depreciation, £600. If their scheme was only to supply what would bring in an income of £1,200, it would only reduce the costs by about £200. With an income of £1,200, therefore, and a scheme accordingly, they would just meet their expenses. Every private house above that would be pure profit. As to the investment being profitable, it depended upon whether they got custom outside the school—£800 of such custom would enable them to pay a dividend of 10 per cent. Any attempt to start a company on a smaller scale would not be economical. It might give the thing a start, but it certainly means a deferred profit. It would be a struggle for years; they would get their electric light, but probably no profit.

The **Rev. W. D. Bushell** questioned Mr. Crompton as to the cost it would mean to the consumers.

Mr. Crompton said that in Kensington the electric light costs 5s., as against gas at 3s. per thousand, but he had known cases where people whose gas bills had been £15 a year had paid £12 or £13 for electric light. This was simply because of the better facilities for turning off and on, and in the case of electricity many lights were saved, which it was not possible to do without in the case of gas.

Mr. Bushell then put a question as to the cost of fittings.

Mr. Crompton said the cost varied. In some cases it was as low as 27s. per light, whilst in the better class of house it was sometimes as much as 45s. a light.

Mr. Bushell: Will £6,000 be all the capital?

Mr. Crompton: £10,000, of which £6,000 would be called up.

Mr. Pitcairn: Is not the alternating system dangerous under any circumstances?

Mr. Crompton: No. Competition has given rise to the statement, but it is absolutely untrue.

Mr. Pitcairn: But it is the high pressure.

Mr. Crompton: It is not brought into houses.

Mr. Pitcairn: Well, accidents might happen in the streets, then?

Mr. Crompton: That means you must have the work substantial. The risks are infinitely less than in the case of gas; but if damage is done it falls on the company, not the consumers.

Mr. Griffiths: In case of a breakdown, will you have extra dynamos?

Mr. Crompton: Yes; one will be held in reserve.

Mr. Paine: Do I understand, as compared with gas, the consumers will pay 5s. a thousand?

Mr. Crompton: A little less—about 4s. 9d.

Mr. Paine: Our public lamps extend for miles, and we are charged at the rate of 4s. a thousand—will you be able to compete?

Mr. Crompton: We should take them at a loss sometimes.

Dr. Stevens: Mr. Crompton has not mentioned street lighting in his scheme.

Mr. Crompton: The Cheltenham Town Council have insisted on the lighting of the town, and the most frequented thoroughfares will be lighted with arc lamps, leaving the outlying streets to be lighted with oil lamps.

Mr. Pitcairn: Here we have a gas which is dear and not so pure as in London.

Mr. Crompton: Unless you have the arc lamps there is very little advantage in having a light outdoors.

Mr. Pitcairn: But you would be a rival to the gas company.

Mr. Crompton: It's a mistake to talk about shutting out gas works. There is a great future for gas for heating purposes, and some look upon the gas jet both as their light and fire. I don't think we shall tread upon each other's toes for the next seven or eight years.

Mr. Paine: Can you point to any place similar to Harrow where it is worked at a profit?

Mr. Crompton: Tamworth, in Australia. There they paid 6 per cent. after the first year.

Mr. Paine: It is not very encouraging over at Barnet. We want to profit by something which is in existence, and not to venture on an experiment.

Dr. Stevens: Is it merely a scheme for the school and the private consumers, or is it to include street lighting?

Mr. Crompton: In drawing up my scheme I have looked to the most certain source of income. I don't want to go in for the lighting of the streets if I can help it.

Mr. Bushell: What is the course to pursue in forming a company?

Mr. Crompton: The company or the Local Board will apply for a license.

Mr. Trevor: Within what sort of radius will your scheme work?

Mr. Crompton: It covers a length of 1,500 yards, but with overhead wires we can supply two or three miles.

Mr. Bushell: How far would the consumers be in the power of the company as to the price varying?

Mr. Crompton: I should say the price would not be raised, as that would mean failure.

Mr. Gunn: Supposing I had 20 lights in my shop and house, would they cost me £40?

Mr. Crompton: I should say about £30 in your case.

Mr. Gunn: That would be a large sum.

Mr. Crompton: We have no difficulty in getting gentlemen to pay it when they find the light answers their purpose.

Mr. Bushell: How many lights would you require in this room?

Mr. Crompton: Four, and they would give a better light than the present.

Mr. Bushell: Then there is the saving in furniture.

Mr. Crompton: Yes; you would find the money paid for white-washing and plumbers' work would soon pay the cost of introducing the electric light.

Mr. J. G. Chapman said the dark ceilings were caused by the coal fires, as he had proved in his own house. He went on to speak of the Electric Light Company at Eastbourne, which, he said, had been reconstructed twice, and which had made no profit at all. Then, for ventilating purposes, gas was found to be necessary. It was used in all rooms of the Hotel Metropole for that purpose. In rooms where the electric light was used the atmosphere was stuffy, and the carbonic acid gas was not carried off, the top of the room being colder than the bottom.

Mr. Crompton agreed that gas assisted ventilation. In the Birmingham Town Hall four gas jets made the most perfect ventilation, but one electric motor would have done the work better. But in large rooms in London, in the season, where there were crushes, the electric

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light caused a comfortable temperature, and there were no draughts to give the people colds. In the bedroom, too, the advantages of the electric light were enormous.

Mr. Holltum asked whether the light was likely to go out. If he had three or four ladies in his shop, and the light went out, it would be rather awkward.

Mr. Crompton said it could be rendered perfectly safe and reliable.

Mr. W. F. Taylor said he should like to make a few remarks about Mr. Crompton's figures. Last year, in a paper read before a meeting of specialists, Mr. Crompton said that the cost of the plant, etc., to supply 10,000 lamps would be £57 000. That evening Mr. Crompton had told them that for 3,000 the capital required would be £6,000, and he would like to know how the two statements could be reconciled. According to his former statement 3,000 would cost £17,928.

Mr. Crompton explained that his former statement had reference to the mains in London, which were far more expensive to make. If Mr. Taylor examined his paper, he would find that the cost for the earthwork was enormous. Opening up streets in London was very different to what it would be here.

Mr. Taylor, having pointed out other differences in connection with the laying of the mains, asked how Mr. Crompton managed to get over the high peak in the load diagram which he was so much afraid of in connection with the alternating system last year, and afterwards remarked that he thought this meeting was on behalf of the ratepayers, and not on behalf of the schools.

The **Chairman** said it was not on behalf of the school.

Mr. Taylor said Mr. Crompton's scheme had only reference to the school.

The **Chairman** said it was not so.

Mr. Taylor said that many important parts of the district would not be reached by the scheme. He should like to know why Mr. Crompton had been invited.

The **Chairman** said he had offered his services, and the Lighting Committee thought it well to accept them. He was sure the Board would have heard any other firms if they had come forward.

Mr. Taylor said they did send a letter to the Local Board asking to be heard before the first meeting was held.

Mr. Paine said, as one of the committee, it looked a little like rushing the matter to have a single firm down without giving any other firms an opportunity to be heard—(**Mr. Taylor:** Hear, hear)—and then to immediately form a committee.

The **Chairman** said he thought it most desirable that a committee should be formed apart from the Board. The Lighting Committee could continue their enquiries if it was wished.

Dr. Stevens said he had had nothing to do with this meeting, although his name had been added to the Lighting Committee.

The **Chairman** said he must apologise for the mistake; he took it to be the ordinary Lighting Committee.

Mr. Dell said they were very much indebted to Mr. Crompton for coming there and putting the matter before them in such a fair and gentlemanly manner. He agreed with the Chairman that it would be better for a committee to be formed apart from the Board to continue the enquiries. They did not wish to ignore Mr. Taylor's company, and would be quite willing to hear them on the subject. He proposed a vote of thanks to Mr. Crompton.

Mr. Marshall said that it was the duty of the Lighting Committee to report to the Local Board, and he hoped they would do so. He agreed that it would be best to have an outside committee to consider the question of domestic lighting, but thought this was hardly the occasion on which it should be formed. Referring to Mr. Taylor's remarks about the school, he pointed out that Mr. Crompton only spoke of it as a nucleus, and added that if the school did have the electric light, it would be serving the town, inasmuch as it would be possible for people then to have this luxury.

Mr. Paine then seconded the vote of thanks to Mr. Crompton, which was carried unanimously, and the meeting terminated.

LEGAL INTELLIGENCE.

EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY v. HOLLAND.

The following judgment in this case was delivered on Monday last. It has, according to our views, been unnecessary to repeat at full length the evidence given in this appeal, as most people outside those immediately engaged in the struggle concern themselves only with the verdict, which is herewith given in full.

The Attorney-General (Sir R. Webster, Q.C.), Mr. Aston, Q.C., Mr. Moulton, Q.C., and Mr. Bremner appeared for the plaintiffs; Sir Horace Davey, Q.C., Mr. Finlay, Q.C., and Mr. J. C. Graham for the defendants (the respondents).

Lord Justice Cotton: This was an action brought against the defendants in respect of two patents, both of which have become vested in the plaintiffs, and they sought to restrain the infringement of those patents. One of them was a patent granted to Cheesbrough. In respect of that Mr. Justice Kay decided in favour of the plaintiffs, and granted an injunction and consequential relief. As regards the other patent, which was one obtained by Edison, and the date is the 10th November, 1879, he decided against the plaintiffs, and hence the appeal. Now this patent has been before this Court, and I had the advantage or disadvantage of being one of the members of the Court on the previous occasion. There was a difference of opinion between myself and the other Lords Justices as to the true construction of the specification, but I consider myself bound by the decision of the Court on that point, and in my opinion, except on questions of fact, which, of course, must be decided by the evidence in this action, the Court ought to consider itself bound by the previous judgment. In the previous case the Court held that if there was no anticipation of the invention claimed by Edison it was a good subject matter for a patent, being for a combination many parts of which were not new, but which was rendered useful by a carbon bridge or burner, described as a filament, which the majority of the court held not to be confined to the particular things described as filaments in the specification, but I think held that it must possess the characteristics pointed out in the specification, must be substantially the same as regards these characteristics, as the particular filaments described in the specification. The Court then decided that the utility of the invention was established. Here then was a great effort made to contest the utility of the invention. This was principally based on the contention that no successful incandescent lamps were made in accordance with the specification of November 10, 1879, and without further improvements. Inventions for the improvement of the carbon filaments followed quickly on the patent of November, 1879, which greatly assisted in the manufacture and durability of the burner of the incandescent lamp of November, 1879. That, in my opinion, was a useful combination, and a patent is not to be defeated simply because subsequent inventions improved the patented article, or because in consequence of subsequent improvements no article was, in fact, made in accordance with the specification. But in my opinion it is established by the evidence that, in fact, incandescent lamps were made by Edison in accordance with the specification of November 10, 1879, and even sent by him to Dr. Hopkinson, and publicly run by him in March, 1880. I do not see any fact now brought before us which ought to induce the Court to depart, or would justify the Court in departing, from the previous decision of the Court on the question of the invention being useful, and being the good subject matter for a patent. But we then come to the objection of want of novelty, which is a question of fact. The only alleged anticipation which I need consider is that of Swan's lamp, "F. J. B. 1," exhibited in December, 1878, and February and March, 1879, by Mr. Swan. In the previous case, on the evidence then before us, I thought this lamp would, on the construction put by the majority of the Court on the specification, be an anticipation. How does the evidence now stand? It is now admitted that the carbon burner of Swan's lamp was formed into its shape before it was carbonised; and this removes one of the points much relied on by the plaintiffs in the former action. But we have now evidence, which was not before the Court in the former action, of what was being done by Mr. Swan and by Mr. Stearn after the experimental trial of this lamp. We have the evidence of Mr. Swan and of Mr. Stearn. We have had before us the lamp "F. J. B. 1," and we have the letters written by Stearn to Swan in 1879 and 1880, which were apparently admitted by counsel to show what was being done by Swan and Stearn. We see that "F. J. B. 1" was treated by them as a failure, and that their attempt to correct its defects led to lamps which differed more widely than did "F. J. B. 1" from the lamp described in Edison's patent. This evidence assists the conclusion at which the Court arrived in the former action that Swan's lamp of 1879 was not a success, and, I think, enables me to come to the conclusion that this lamp was an experiment which failed, and was abandoned, and that the difference introduced by Edison was one which changed failure into success. But it was contended by the respondents that, in fact, Swan had used for electric lighting incandescent lamps with carbonised thread burners before the 10th November, 1879. Two witnesses, Proctor and Heaviside, stated that carbonised thread lamps were, in 1879, used by Swan. There is no ground for imputing dishonesty to these witnesses, but there was direct evidence by Swan that he did not make any thread-carbon lamp before 1880, or before a fire, the date of which is fixed as 17th January, 1880, and I am satisfied that the witnesses were mistaken in fixing the date as 1879. Reliance was placed by the respondents on a lamp made by Bernstein, not as an anticipation of Edison's patent, for it was not made till after 1879, but as showing that Swan's lamp was a practically useful one. But though Bernstein's lamp has a bridge or conductor, a pencil of carbon like "F. J. B. 1," it has a different junction with the leading wires, which probably obviates some of the difficulties which prevented Swan's lamp becoming a success. Then I come to an objection which was much relied on by the defendants, which was not raised in the former action, and which is now supported by a great deal of evidence. The objection, taken as a whole, was that the specification did not sufficiently show how the invention is to be carried into effect. It is necessary that this should be done, so as to be intelligible and to enable the thing to be made without further invention; not as was pressed on us by an ordinary workman, but by a person described by Lord Ellenborough in Huddart *v.* Grimshaw (Webster's Patent Cases, pages 85-87), as a person skilled in the particular kind of work, or as said by Lord Loughborough, in Cartwright *v.* Nightingale (Webster, page 6), a person conversant in the subject. But in my opinion it is not necessary that such a person should be able to do the work without any trial or experiment, which, when it is new or especially delicate, may frequently be necessary, however clear the description may be.

One of the principal subjects of attack was that part of the specification which gave directions for making a combination of lampblack and tar to form a material to make the filament to be carbonised. Before the experiments which, by the direction of Mr. Justice Kay, were made under the supervision of Prof. Stokes, the defendants' witnesses said that useful filaments could not be made out of the material, and Prof. Crookes was particularly strong in his ridicule of the idea that tar putty could be practically useful. Gimingham, a young man in the employ of the plaintiffs, produced and proved lamps with burners made of tar putty filaments, and after the experiments made before Prof. Stokes the defendants contended before us, without any support from the evidence, that the material could not be effectually prepared without a trade secret which they said had only recently, during the course of the trial of the action, come to the knowledge of the plaintiffs, and probably had been communicated from

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America. It was said that the secret was the necessity of kneading the material for a length of time, and with the exercise of great pressure. In fact, Gimingham had for the trial of the previous action made lamps with tar putty filaments which were made exhibits in this action, and though there are no express directions in the specification how this tar putty is to be prepared, it is stated that the material can be rolled into threads as small as 7-1,000ths of an inch, and I think it would be obvious to any intelligent workman who wished to prepare the material that it must be kneaded so as to make it perfectly homogeneous, and to prevent any breaking of the thread in consequence of any particle of lampblack not being perfectly amalgamated with the tar. I think that this objection fails. But it was contended that lamps with tar putty filaments had not sufficient endurance to make them practically useful. No point was made of this before Prof. Stokes, so that no experiments were made to test this question. In fact, on the evidence before us, many of these lamps were shown to have run for a sufficient time to prove that they could not be considered failures in this respect. Another objection taken to the specification was that no sufficient directions were given as to the carbonisation of the filament. The specification says (page 3) "a cotton thread properly carbonised," and speaking of the thread of tar putty, that the "tar may be carbonised in a closed chamber by subjecting it to a high heat," but no directions are given as to how this is to be done.

Before the experiments made under the supervision of Prof. Stokes, it was said that carbonising the filament in a closed chamber without any packing, or with a packing of sand, which was suggested by Sir F. Bramwell, was impossible, as the filament would be reduced to ash. But this was proved to be unfounded, and before us it was still contended that no sufficient directions as to the mode of carbonisation were given. Carbonisation was a well-known term. The ordinary process may be described as roasting without the presence of oxygen. This was well known and practised before the date of the patent, and Sir Frederick Bramwell in his evidence said that any person who knew the ordinary process of carbonising would succeed in carbonising filaments. But it was strongly contended by the defendants, and by some of their witnesses, that such slender things as filaments could not be carbonised in a closed chamber without being protected by packing, which the specification did not direct to be adopted. In fact, filaments were, as sworn by the witnesses of the plaintiffs and demonstrated by the experiments made before Prof. Stokes, successfully carbonised in closed crucibles or boxes without any packing; moreover, though the specification says nothing about packing, any skilled workman conversant with carbonisation would take the ordinary process of packing to exclude oxygen, and would, I think, know that when so delicate an article as a filament is to be carbonised, the greatest care would be necessary to prevent any possible access of oxygen. It is true that there was no trade in carbonising anything so delicate as these filaments, but great care only in exercising a known process and applying it to an unusually delicate article, and no invention would be necessary. When the defendants' witnesses failed in carbonising the filaments, I think that they did not use reasonable care to exclude oxygen, as shown in the case of using porous crucibles. I am of opinion that this objection also fails.

Another point urged by the defendant was that the coating with a non-carbonisable substance was injurious. The result of the evidence is that when the coating is a thin one the process can be and is done without any injurious results. But then it was objected that the specification did not direct the thin coating; and it was objected, and so held by Mr. Justice Kay, that this thin coating was a mere pretence of coating, and it was dusting only. But it appears from the evidence of Mr. Crookes that he had himself, in fact, adopted the same method as was adopted on behalf of the plaintiffs for this coating. The process was, I think, in the specification, proposed as preventing the filament of tar putty from sticking together during the process of carbonisation, and what I have said about Mr. Crookes, I think, shows that the process which produced the so-called dusting must be considered as that which would naturally be adopted. I think that this objection also fails.

I have dealt with the principal points urged by the defendants, though shortly, in order to avoid the extreme length which would be necessary if I were to deal minutely with the various points. In my opinion the plaintiffs are entitled to judgment, and the appeal must be allowed.

Lord Justice Lindley: The validity of the patent in question on this appeal is disputed on two broad grounds—viz. (1) because the patentee has not particularly described and ascertained the nature of his particular invention; (2) because he has not particularly described and ascertained in what manner the same is to be performed. The 9th Section of the Patent Act, 1852 (15 and 16 Victoria, chapter 83), under which the plaintiffs' patent was granted, imposes upon the patentee the necessity of complying with both of these conditions in order to sustain his patent, and the patent is bad if he fails to perform either of them. The two conditions, although often confused and overlapping, are really distinct, and it is always necessary to keep each clearly before one's mind, and not to commit the mistake of supposing that compliance with one is necessarily compliance with the other.

The first condition imposes upon the patentee the necessity of stating in clear and intelligible language what his invention really is, so that others may know what addition the patentee has made to what was known before, so that they may know what they are not at liberty to do without his consent during the existence of the patent; in other words, so that they may know what the monopoly is that is granted to the patentee. The nature of the invention must be stated both in the provisional and in the complete specification; but, whilst it is sufficient in the provisional specification to state the nature of the invention in general terms, it is necessary in the complete specification to "particularly describe and ascertain it."

The second condition imposes upon the patentee the necessity of stating in clear and intelligible language in which manner the patented invention is to be performed, so that others may learn from the specification how practically to avail themselves of the patented invention when the patent has expired; how they are to do what is necessary to carry out the new invention, the nature of which has been previously described. This condition applies to the complete specification only; there is no necessity to state in the provisional specification how the invention is to be performed.

With reference to the degree of clearness and distinctness of the language necessary to be used in order to comply with those conditions, it is obvious that no hard and fast rule can be laid down, the degree of clearness can only be stated in language which itself admits of considerable latitude in its application. On the one hand, the patentee must make the nature of his invention and how to perform it clear and intelligible; on the other hand, it is not necessary for him to instruct persons wholly ignorant of the subject matter to which his invention relates in all that they must know before they can understand what he is talking about. The patentee is adding something to what was known before, and he does all that is necessary, as regards the language he uses, if he makes the nature of his invention and how to perform it clear and intelligible to persons having a reasonably competent knowledge of what was known before on the subject to which his patent relates, and having reasonably competent skill in the practical mode of doing what was then known. In complying with the first condition—*i.e.*, in describing the nature of his invention—the patentee does all that is necessary if he makes the nature of his invention plain to persons having a reasonably competent knowledge of the subject, although from want of skill they could not themselves practically carry out the invention. In complying with the second condition—*i.e.*, in describing in what manner the invention is to be performed—the patentee does all that is necessary if he makes it plain to persons having reasonable skill in doing such things as have to be done in order to work the patent, what they are to do in order to perform his invention. If, as may happen, they are to do something the like of which has never been done before, he must tell them how to do it if a reasonably competent workman would not himself see how to do it on the reading of a specification or on having it read to him. The principle to be applied to the language used to comply with the two conditions is the same for both; but one class of persons may understand only one part of the specification and another class only the other, and yet the patent may be valid. In a well-drawn specification the two conditions that have to be complied with are kept distinct; but in many specifications this course is not pursued. The nature of the invention and the manner of performing it are often described together. It may be that one set of words sufficiently discloses both the nature of the invention and the mode of performing it, as in Boulton *v.* Bull. But it may be, and sometimes is, very difficult to sever the two, and to see whether both are sufficiently described. Still, if they are, in fact, sufficiently described, the conditions must be held to be complied with, however difficult and troublesome it may be to arrive at the conclusion.

I have been induced to dwell at some length on the above matters, because of their importance in the present case, and of the danger of losing sight of the principles by which the Court ought to be guided in deciding it.

I proceed now to enquire whether these two conditions have been performed, and I will take them in the order in which they logically present themselves. First, as to the nature of the invention. This Court has had to consider this patent before; and, although there was a difference of opinion amongst the members of the Court, the decision of the Court was, as I understand it: (1) That the expression "carbon filament," on which so much turns, was sufficiently clear and definite; (2) that the nature of the invention was sufficiently described and ascertained, and was summed up in the second claim; (3) that the second claim was in substance a claim to "every combination of any carbon filament with any receiver made entirely of glass, through which any leading wires pass, and from which the air is exhausted"; (4) that the plaintiffs' "carbon filament" was essentially different from the carbon pencil used by Swan in his lamp, "F.J.B. 1," and that Swan had not by that lamp anticipated the plaintiffs' patent. The patent was upheld, notwithstanding the very wide nature of the second clause as construed.

This decision is, in my opinion, binding on us so far as the construction of the specification is concerned, but no further. I do not regard the decision as binding us upon the questions whether the conditions to which I have alluded have been performed or not; for these questions depend not only on the construction of the specification, but on evidence as to the previous state of knowledge, and as to whether a person of reasonable skill could, at the date of the patent, carry out the invention without further instruction than the specification gave him. I have, therefore, whilst taking the construction of the specification as settled, considered myself at liberty to exercise my own judgment on the effect of the evidence in this litigation.

The construction of the specification which I consider binding involves three points—viz.: (1) that the specification is not too vague and unintelligible to be construed by the Court; (2) that what is meant by "carbon filament" is reasonably plain from the specification itself; and, thirdly, that the second claim as construed by the Court is not so wide as to invalidate the patent. The meaning of the expression "carbon filament" appears to me to be the crucial point for determination when dealing with the question whether the nature of the invention is particularly described. This point, moreover, is, in my judgment, by far the most difficult in the whole case. Everything, I think, turns upon it; but as I was not a party to the decision, and the case will probably be appealed, I think it desirable to state that after much consideration and doubt I have come to the conclusion that what is meant by the expression "carbon filament" can be gathered from the instances given in the specification

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and that what is meant is any thread which can be and is bent into the required form, and can be and is carbonised when so bent. The thread, as shown by the examples, may be a fibre or a group of twisted fibres, or, as is to be gathered from the tar lampblack instance, it may be an artificial substance pressed or rolled into thread or wire-like forms. The evidence shows that at the date of the patent the expression "carbon filament" was new as applied to electric lighting. Its meaning, or, in other words, the sense in which it is used by the patentee, must therefore be gathered from the specification. The sense in which the patentee has used the expression "carbon filament" can, in my opinion, be gathered from the typical examples given in the specification and referred to in the judgment of Lord Justice Fry in the former case. At the top of page 253 the Lord Justice says: "It is not needful for us to pursue the description of all the processes given by the specification, but we will refer to the forms of carbon conductor described. The first form referred to as suitable is a 'cotton thread properly carbonised,' which is stated to offer from 100 to 500 ohms resistance to the passage of a current; the second form of conductor referred to is any fibrous vegetable substance which will leave a carbon residue after heating in a closed chamber. To this class may be referred the cotton and linen thread wood splints, and paper coiled in various ways to which Mr. Edison refers. The fourth form is such fibrous material as before mentioned, rubbed with a plastic compound of blacklead and tar. The fifth form is a carbon filament made of a combination of tar and lampblack, or plumbago or carbon in other forms, the lampblack and tar being subsequently carbonised by being subjected to high heat in a closed chamber. Mr. Edison observes that small pieces of such a compound may be rolled out in the form of a wire as small as seven one-thousandths of an inch in diameter. The sixth and last form described is a carbon filament of the kind lastly described, but coated for the purpose of support with a non-conducting, non-carbonising substance." The size of the filament is not stated; but it is quite clear from the objects to be attained that it must be long and thin, and nothing more definite is necessary to be stated.

Having arrived at that conclusion, it follows that in my opinion the patentee has "particularly described and ascertained the nature of the invention."

The next thing is to consider whether he has sufficiently described "in what manner the same is to be performed." This is a pure question of fact, and is in no way touched by the previous decision of the Court. Mr. Justice Kay, however, has found this against the patentee. Having carefully attended to the evidence and to his judgment, I have come to the conclusion that I am unable to agree with him; and I cannot help doubting whether he would have arrived at the same conclusion if he had had the advantage which we had of hearing the Attorney-General's reply to his opponents.

The defendants, in the first place, endeavoured to make out that carbon filaments could not be made as described by the patentee. The evidence on this point was so conflicting that Mr. Justice Kay called in an expert to assist him. This gentleman's report is absolutely conclusively in favour of the patentee, upon the question whether carbon filaments can or cannot be made as described. Beaten on this point, the defendants contend that no competent workman could have made carbon filaments according to the specification without further instructions than are there given. If it be meant that few competent workmen could make them without some practice, I think the contention is well founded; but this is not sufficient to invalidate the patent. If a person is told to carbonise a thread, and for want of thought or practice he takes a porous crucible for the purpose, and does not protect his thread and fails, when, if he had packed this crucible, or had taken a non-porous crucible, he would have succeeded, his failure can hardly be said to be the fault of his instructor, if a little thought and consideration would have shown that a packed crucible or a non-porous crucible was the right one to employ. The fact that a workman may use a wrong tool when he has a right one, which a little thought will lead him to see ought to be used, does not warrant the inference that a specification is bad if it does not tell him which tool to use.

Again, with respect to tar putty: the object to be attained is plain; the putty must be kneaded so that it can be rolled out thin without a break or flaw. Practice alone can teach any man how long and how hard he must knead. If he stops too soon and fails, is it the fault of the patentee? I should say certainly not. A similar observation applies to coating with a non-conducting, non-carbonisable substance. If the coating is made lightly by dusting all goes well; if too much is put on failure is the result: a little practice is all that is required. Mr. Crookes himself tried dusting as the most natural way of coating; and the unsuccessful coating experiments were not repeated before Prof. Stokes. I feel the great difficulty of describing in words the distinction between an amount of practice without which failure is probable, but the necessity for which does not destroy a patent, and an amount of experiment and invention, without which failure is certain, and the necessity for which destroys a patent. The test, however, by which to decide such a question is, I think, to be found by asking whether anything new has to be found out by a person of reasonably competent skill in order to succeed if he follows the directions contained in the specification? If yes, the patent is bad; if no, it is good so far as this point is concerned. Practice is one thing; experiment and trial are something different. On this point I derived considerable assistance from the judgment of the late Master of the Rolls in Plimpton *v.* Malcolmson, and from the judgments in Simpson *v.* Halliday and Macnamara *v.* Cooke. It is settled that a patentee who does not disclose the best method known to him of carrying out his invention does not comply with the second of the conditions to which I have before referred. But if a patentee says that something must be done which a reasonably competent man would know how to do, the patentee need not tell him how to do it, nor warn him to be careful, and to exercise such forethought and attention as the delicacy of the process to be used, or the material to be employed plainly demand.

The evidence upon the question whether at the date of the patent a reasonably competent man could make carbon filaments without further instruction than is given in the specification, or without further experiments, was undoubtedly conflicting, and Mr. Justice Kay, who saw the witnesses, came to the conclusion that further instruction and experiment were necessary. The Attorney-General, however, convinced me that on this point Mr. Justice Kay was mistaken. I cannot myself come to the conclusion that the patentee has kept back any secret that he possessed by virtue of which he could in 1879 make carbon filaments better than other persons possessed of reasonable skill, and who followed the directions contained in the specification with a *bona fide* desire to succeed. To ensure success, all that is necessary is carefully to follow the instructions there given, bearing in mind the objects to be attained, and that the filaments are extremely delicate and easily destroyed. That is, in my opinion, the fair result of the evidence; and the fact that Edison in later patents gave particular instructions as to the mode of carbonising, etc., only shows that he had then ascertained that those instructions were necessary to enable a competent man to attain the desired results. It cannot, I think, be inferred that in 1879 special instructions were necessary to enable reasonably skilful men to do what the specification of that date said must be done. The evidence on this matter is no doubt conflicting, but I cannot agree in thinking that the manner in which the invention is to be performed is not stated with sufficient clearness to support the patent. If this were really true it would have been found out long ago, at least so far as carbonising is concerned.

There remain, however, two other matters for consideration—namely, novelty and utility. The novelty depends on whether Swan's lamp, "F. J. B. 1," was an anticipation, for I am convinced that Proctor and Heaviside are wrong in the date they assign to the hairpin lamps made by Swan. The correspondence referred to by the Attorney-General is conclusive as to this matter. The lamp "F. J. B. 1" was held by this Court, in the action against Woodhouse, not to be an anticipation of the plaintiffs' patent, but it was then supposed that the carbon pencil used in it was carbonised after and not before it had assumed its final shape. This was a mistake, and was admitted to be so in this action.

The question of anticipation must be considered anew on the evidence before us. If Swan's lamp "F. J. B. 1" had been a success instead of a failure, it would, in my opinion, have been an anticipation of the plaintiffs' patent. The evidence, however, shows that it was a failure, and that Swan had not got the key to success. His own efforts to improve this lamp show that he was not thinking of filamentous incandescent carbons, but of other matters. Still, his lamp did give light for a time, and was very near, though, in my opinion, not quite, an anticipation. It was, in truth, an unsuccessful experiment. I agree with Lord Justice Fry in thinking that the point at which Mr. Edison's instrument departed from Mr. Swan's was crucial, and the departure, though slight, had all the merits of a new invention, and produced a new apparatus. Regarding the lamp "F.J.B. 1" as an unsuccessful experiment, this part of the case is governed by the principle of Murray *v.* Clayton, 7, Chancery Division, page 570.

The question of novelty, which I am now considering, is closely connected with, although really different from, the question as to the sufficiency of the description of the nature of the patented invention. Given Swan's lamp "F. J. B. 1" can it be said that Mr. Swan added anything to what was known at the date of his patent, and that he sufficiently described the nature of what he added? In my opinion he did; not, indeed, in words, distinguishing his lamp from Swan's, but by giving and describing a new type of body to be rendered incandescent, or, if I may use such an expression, a new type of thread. One mode of trying this question is to ask whether anyone would make such a thing as Swan's lamp, "F. J. B. 1," if he took Edison's specification as his guide. I am convinced he would not. He would avoid and not reproduce Swan's carbon pencil, and would adopt Edison's type of carbon in the carbon filament. The two may be made to shade off into each other until it becomes impossible to draw the line sharply between them; but this does not prevent a man from perceiving the difference between the two types, or from adopting the one which succeeds in preference to the one which fails.

There remains the question of utility. Edison's patent is said to be of no use; and the proof of this statement is said to be furnished by the fact that lamps are not made according to the patent even by Edison himself. The utility of the patent must be judged by reference to the state of things at the date of the patent; if the invention was then useful, the fact that subsequent improvements have replaced the patented invention, and rendered it absolute and commercially of no value, does not invalidate the patent. Such has been the fate of lamps made in the way described in Edison's specification. Such lamps appear to have been made and sent to England, but they were so soon improved that they at once ceased to be used in their original form. But lamps having the carbon filaments in combination with the other essentials mentioned in the second claim are in constant use, and their utility is proved by the fact that this particular combination is used by the defendants, and by everyone, in fact, who makes incandescent electric lamps. The utility of the patented invention, meaning thereby the above-mentioned combination, is incontestable; and Mr. Justice Kay's opinion to the contrary is, I think, to be attributed to the view he took of the construction of the patent, a matter which, as I have said before, I consider settled by the previous decision of this Court.

Before concluding, I ought to notice the very formidable objection taken by Mr. Justice Kay to the validity of the patent, on the ground that the second claim is for a monopoly of incandescent lamps containing a filament of carbon for a burner, and that such claim is far too wide, considering how much Edison had invented. Whether the view here taken of the patent is correct or not turns, in my opinion on what Mr. Edison did when he introduced "carbon filaments." That was, I think, a new departure of the highest importance in elec-

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tric lighting, and if this be so the claim is not too wide. See Househill Company v. Neilson (Webster, page 683).

For the reasons above stated, I am of opinion that this patent, construed as it has been by this Court, is valid, and that the appeal ought to be allowed.

Lord Justice Bowen: In order not to add more than is necessary to the voluminous literature on the subject of this patent, I will express my views as briefly as possible. As regards the construction of the second claim, I think we ought to follow, on principle, what has been already decided by the majority of the Court in the case of the former action; but as I retain the same opinion as I then formed, this point becomes less material. The patent appears to me to claim in distinct and unmistakable language every combination of any carbonised filament with any receiver of glass, through which leading wires pass, and from which the air is exhausted. Whether a claim so framed is too vague or too wide, or unfit to be the subject of a patent, or whether it is wanting in novelty or utility, constitutes an enquiry which, in parts at all events, may be said to be bound up with questions of fact, and, as far as all such points are concerned, I think it desirable to judge this appeal *de novo* upon its independent merits.

Construing claim two as embracing all combinations such as I have mentioned, is it too vague? I see no reason to doubt that in the year 1879 the term filament, though new at that date as regards electric lighting, would, nevertheless, convey to the minds of ordinary persons of the class to whom this specification was addressed the idea of a slender thread or thread-like substance, and it seems to me that the specification indicates that the thread or filament was first to be formed and then to be subsequently carbonised. On page 2 of the patent, the thread is distinguished from a rod. "Heretofore, light by incandescence," says Mr. Edison, "has been obtained from rods of carbon. I have discovered that even a cotton thread, if properly carbonised," will produce the requisite effect. The instances given in the specification, which are enumerated in the judgment of Lord Justice Fry and myself in the previous appeal, and in the judgment of Mr. Justice Kay in the present action, are illustrations of the sense in which the term, which appears to me to be in itself intelligible, is used. The term filament is nowhere defined. It is a descriptive term, not a definition. But it appears to me to indicate the nature of this particular factor in the combination in a way that describes and ascertains the nature of the invention so as to render it plainly intelligible to a skilled person of the class to whom the specification is addressed—languages which embodies old law, but which is tersely expressed in Lord Herschel's judgment in the Badische Anilin case (2. Appeal Cases). The merits of the filament, as distinguished from a rod, are manifest. The filament, or thread, has an extremely small sectional area; it is flexible before carbonisation, and resilient afterwards. It is true that these merits are not explained, but I know of no law which renders it incumbent on the patentee in such a case to explain them. It appears to me, moreover, to be proved, not only that every successful lamp since 1879 which is available for multiple arc lighting has employed a filament, but also that there is no proof yet that any filament cannot be adapted to the patented combination. If this is so, why is the claim too wide? It is not the fault, but the virtue of the invention that it covers so large a field.

We have been pressed with the argument that the Edison patent is useless, and that no lamp in the market has been made exclusively on the patent of 1879 without the aid of subsequent improvements. Improvements of real value followed with great rapidity on the patent, and were naturally utilised. Their rapid succession does not destroy the legal validity as regards usefulness of the original combination to which such improvements were felicitously applied. The utility of this invention, which was admitted in the Woodhouse case, has been challenged in the present action, but I think unsuccessfully, and the evidence shows that lamps made solely on the patent will and do succeed, although subsequent improvements have been generally engrafted on the original design.

Was "F. J. B. 1" an anticipation? We know now what the Court did not know in the last action, that the carbon conductor in "F. J. B. 1" was formed before it was carbonised. Was it a filament? The question is one of degree. I doubt whether it is one, and I still more doubt whether anyone who saw it would understand it to be such. But in any case I think "F. J. B. 1" never was more than an experiment which was unintelligible on account of its failure and barren of all fruit, and which was regarded even by its inventor as practically valueless in the race. The correspondence between Messrs. Swan and Stearn shows, I think, to demonstration that till the middle of the year 1880 Mr. Swan did not consider himself to be upon the right track. The dates put forward by the witnesses Proctor and Heaviside seem to be unreliable and inaccurate, and I think there is reason for believing that it was Mr. Edison's patent which led back the world of electricians to the true path. Certainly from the date of its exhibition the lamp "F. J. B. 1" disappeared from history, until it was exhumed for the purposes of the trial in the Woodhouse case.

With respect to the remaining points raised in argument before us, I have nothing to add to what has been said by my brothers. I think this patent constituted a new departure in electricity; that the specification sufficiently describes and ascertains the nature of the invention; and that no reasonably competent operative alive to the delicacy and care obviously requisite in forming and carbonising so slight a thing as a filament ought without any exercise of invention, but with reasonable watchfulness only and fair goodwill, to have been embarrassed in making and carbonising Mr. Edison's filaments. The appeal in my judgment should be allowed with the ordinary results as to costs; and I think I ought, in conclusion, to express my own personal obligation for the conspicuous clearness and ability with which this case has been placed before us at the bar.

A long argument took place as to the exact position the Anglo-American Brush Company was to take in this case, the plaintiffs claiming to treat as defendants the corporation, which was a third party in the suit. The final result of the argument will be seen in the discussion by the judges, as follows:

Lord Justice Cotton: A point has been raised here which is a curious one, but it arose simply after judgment, and I thought the matter was simply giving the judgment now to apply to both patents, which Mr. Justice Kay had given as regards the one which he decided in favour of the plaintiffs. But the plaintiffs now claim to treat the third parties as if they were defendants, not only in the way of making them pay costs, but also in the way of granting relief against them—granting an injunction, and consequential relief. As regards that, I think it would be wrong, because the third parties are not defendants. If a plaintiff has a direct claim against a third party, as soon as that is known the proper course is to amend the statement of claim and make him a defendant, and then the Court has all that jurisdiction as against the defendant, which it gains by serving that party with a writ, and bringing him in as a party to the action. Why that was not done here I cannot understand, except that possibly the plaintiffs did not like to bring in another person against whom they would be liable to costs, as they did before Mr. Justice Kay as regards this portion of the Edison patent.

One does not wish that there should be unnecessary litigation. I do not see that for that reason one could assume a power which, in my opinion, we have not got. It is very true that when this third party came in and desired to defend the action, and the direction was given, he might have had that liberty given on his undertaking to submit to any judgment which the Court might think fit to give as against him, supporting the interest of the defendant, and really being the person who ought to have been made defendant. But that was not done. The order which was made was simply an order in these terms, that he should be at liberty to appear at the trial of the action, and take such part therein as the judge shall direct, and the said Anglo-American Brush Electric Light Corporation, Limited, shall be bound by the decision of the Court in this action in any question as to the above indemnity which may arise between that company and the defendants. If the plaintiffs were not satisfied with that, they ought to have said, "No, that will not do for us, other terms ought to be imposed upon this third party;" but the proper course, looking now still to the origin of the jurisdiction, and that which brings a person within the jurisdiction of the Court, ought to have been for the plaintiff to amend his appeal, and say: "Here are the real persons who are disputing or infringing this patent, and who are making these things, which I say are infringements of the patents." That course was not taken for some reason; I do not know why. In my opinion, we have no jurisdiction to make a decree against this third party as if he were a defendant, and to grant an injunction against him and grant damages against him in this action as if he were made a party. Whether he will be unwise enough to dispute the plaintiffs' rights as regards this patent when another action is brought against him I cannot suppose. But then the Attorney-General says, Give me leave to amend, and Mr. Aston says that we ought to make such order as the Court ought to have made below, and to make such amendments as may be necessary for that purpose. But what was the course taken by the plaintiff on the trial in the Court below. In the Court below they never asked for this relief as against this third party. It is very true there was an expression by Sir Horace Davey which was relied upon, that the third party sought to be put in direct relation to the plaintiff. I do not quite understand, myself, what that meant. It is not as clear as Sir Horace Davey's expressions usually are, but these parties did not act on that, and treat it as a statement that the third party should be made a defendant. It may have been immaterial then, because the costs given to the defendant were the costs of the defendants as regards that part of the action in which the plaintiff failed, and costs were given as against the defendant as regards that part of the action on which the plaintiff succeeded. In my opinion it would be wrong, under those circumstances, and in the course which has been adopted by the plaintiffs now, to grant liberty to amend to enable the Court to give different relief against the third party than that which was asked for at the trial of the action.

Now, as to the costs. As regards the costs of the appeal, as the third parties do appear on the appeal, and as they were served with notice of appeal, there will be no difficulty in making an order against them for payment of the costs of the appeal, and in my opinion the Court has jurisdiction, having regard to Rule 54, to make them pay the costs. Therefore, as regards this part of the action, I think it would be wrong to alter the judgment. As regards the other part of the action we may, when we alter the judgment of Mr. Justice Kay, make an order against the third party as well as against the defendants for payment of the costs of the action.

Lord Justice Lindley: In substance the third parties here are the people who fought the plaintiffs, and if I had tried the case and come to the same conclusion I have done on the merits, and had been asked to amend by making the third parties defendants, I should have done it without the slightest hesitation, and I am not at all sure, if I were sitting alone on the appeal, I should not do it now. I think there is power to do it, but I will not differ from my learned brother on that point. There is a little doubt as to whether it ought to be done, and so let in the very wide terms of Order 28, Rule 1. When you see, at least apparently, that no conceivable injustice can be done—there are no merits in it, it is a mere matter of form—I should get over it. However, as I say, there has been no amendment. As to costs there is no difficulty at all. Rule 54 of Order 16 clearly gives power to make what order we think right as to costs. Now, what order is right? Those who really fought the plaintiffs and failed should pay the costs. The order will be that the third party do pay the costs here and below.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the week ended February 15 amounted to £5,346.

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COMPANIES' MEETINGS.

INDIARUBBER, GUTTAPERCHA, AND TELEGRAPH WORKS, LIMITED.

The twenty-fifth ordinary general meeting of this Company was held last week at the City Terminus Hotel, Mr. S. W. Silver presiding.

The **Chairman**, in proposing the adoption of the report and the declaration of a dividend of 5 per cent., tax free, stated that the operations of the Company had expanded in the past year fully in proportion to the improvement in the general trade of the country. Their general sales had exceeded those of any previous year, showing that their works were in a condition to meet any demand that might be made upon them. Owing to the keen competition against which they had to contend, he was not in a position to state that their profit was at all in accordance with the amount of the sales; nor must they look for that unless they went into new fields and sought for new outlets such as those connected with electricity. The year's working had resulted in a net profit of £57,157, which was increased by the amount brought forward to £66,687. They recommended a dividend of 10s. a share, or 5 per cent. for the half-year, making with the dividend paid last July a return of 10 per cent. for the year; and they would carry forward £25,000. In regard to the submarine branch of their business, they had done little as compared with their resources, their staff, etc., but they were now very much better employed, and they were likely to be for months to come, and their vessels would have something to do. No profit had been taken on account of the new cables.

Mr. Abraham Scott seconded the motion.

Mr. Cochrane complained of the amount paid to the Directors for their remuneration.

In reply to questions, the **Chairman** stated that any shareholder could give notice for altering the Directors' remuneration. Their steamers had done comparatively little work during the past year. The gross profit included the profit made by them on the sale of some securities.

The motion was adopted, and the retiring Directors and Auditors were afterwards re-elected.

NEW COMPANIES REGISTERED.

Sunderland and District Electricity Supply Company, Limited. Registered by Slaughter and May, 18, Austinfriars, London, E.C. Capital £100,000, divided into 100,000 shares of £1 each, of which numbers 1 to 100 shall be founders' shares entitled to 25 per cent. of the profits. Object: to form centres in the county of Durham from which electric power may be generated or accumulated, and for distribution of the same for lighting, heating, and other purposes. The first subscribers are:

	Shares.
J. Y. Short, Sunderland	1
J. H. W. Culliford, Sunderland	1
J. Sanderson, Sunderland	1
R. Hammond, 117, Bishopsgate-street, London, E.C.	1
F. Pinkney, Sunderland	1
U. S. Barwick, Sunderland	1
W. Pinkney, Sunderland	1

There shall not be less than four nor more than nine Directors of the Company, and the first shall be appointed by the subscribers to the memorandum of association. Each Director shall hold at least £500 in the capital of the Company. The remuneration shall be the sum of £250 per annum, and one-tenth of the net profits after payment of 7 per cent. dividend per annum.

CITY NOTES.

West India and Panama Telegraph Company.—The receipts of this Company for the half-month ended February 15 show a decrease of £378, as compared with the corresponding period.

Western and Brazilian Telegraph Company.—The traffic receipts of this Company for the past week, after deducting the fifth gross earnings payable to the London Platino-Brazilian Company, were £4,506.

Telegraph Construction and Maintenance Company, Limited. Including £50,436 brought forward, the accounts of this Company for the past year show an available balance of £133,016, from which a distribution of 20 per cent. is recommended, 5 per cent. having already been paid on account. There will then remain £43,376 undivided.

London Electric Supply Corporation.—This Company has appealed to the public with an issue of £250,000 6 per cent. preference shares of £5 each. The prospectus states that the Corporation's central station at Deptford consists of freehold premises nearly four acres in extent, with a fine river frontage on which buildings are now in course of erection, and will shortly be completed. These buildings will eventually contain generating plant for 850,000 lights. At the present moment machinery for 250,000 lights is being erected, a portion of which will be in operation in the course of the next three months. The premises having been laid out with the view to further extensions, a very considerable portion of the first outlay that has been incurred is for future developments, so that all such extensions will be made at less relative cost than could otherwise be the case. The engines are of the marine type and will be of 10,000 h.p. each, with the exception of two of smaller dimensions (1,500 h.p. each). The dynamos are the well-known machines of Mr. S. Z. de Ferranti, the Corporation's engineer.

PROVISIONAL PATENTS, 1889.

FEBRUARY 11.

2375. **Improvements in the construction of telephones.** Samuel Benjamin Wilkins, 1, Parliament-square, Edinburgh.

2406. **Improvements in the mechanism of electric arc lamps.** John Roper, 2, New-street, Huddersfield. (Complete specification.)

2407. **Improvements in dynamo-electric machines.** Alexander Bernstein, 4, South-street, Finsbury, London. (Complete specification.)

FEBRUARY 12.

2472. **Improvements in secondary batteries, and plates or elements therefor.** William Lloyd Wise, 46, Lincoln's-inn-fields, London, W.C. (The Gibson Electric Co. of Europe, France.)

2476. **An improved electrical alarm.** Samuel Sudworth, 6, Estelle-road, South Hampstead, London, N.W.

2480. **Improvements in and relating to apparatus for measuring electric currents.** Henry Harris Lake, 45, Southampton-buildings, London. (Henry Henderson Cutler, United States.) (Complete specification.)

FEBRUARY 13.

2536. **Lighting, cigars, pipes, &c., by electricity.** Thomas Wm. Watson and Arthur Henry Watson, 4, Pall-mall, London, S.W.

2544. **Improvements in the form and manufacture of secondary battery frames and plates.** Arthur Douglass and Frederick Smith, 4, Danes-inn, Strand, London.

2567. **Improved means and apparatus for electrically driving vehicles.** Paul Bedford Elwell and John Kemp Starley, 17 and 18, Southampton-buildings, W.C.

FEBRUARY 14.

2614. **Improvements in electric meters.** Joseph Oulton and Joseph Edmondson, Town Hall Buildings, Halifax.

2628. **Improvements in electric contact and alarm thermometers.** Max Stuhl, Joseph Mathias Lautenschläger and Franz Lautenschläger, 142, Fleet-street, London. (Complete specification.)

2642. **Improvements in dynamo-electric machines.** George Forbes, 24, Southampton-buildings, Chancery-lane, W.C.

2646. **Improvements in apparatus or means for metering electric currents.** William Harding Scott and Laurence, Paris, and Scott, 47, Lincoln's-inn-fields, London.

FEBRUARY 15.

2694. **Improvements in apparatus for the measurement of electrical resistances.** Walter Thomas Goolden and Sydney Evershed, 46 and 47, Temple-chambers, Temple-avenue, E.C.

FEBRUARY 16.

2742. **Improvements in automatic switches for suspended "arc" lamps.** Frederick Wagg and Washington Hudson, 6, Egerton-road, Greenwich, S.E.

2748. **Improvements in telephonic switching apparatus.** Alfred Rosling Bennett, 62, St. Vincent-street, Glasgow. (Complete specification.)

SPECIFICATIONS PUBLISHED.

1887.

7530. **Electrical transformers.** Statter. (Complete specification.) 8d.

1888.

925. **Electric measuring, &c., apparatus.** Lorrain. 1s. 8d.

1386. **Telegraph insulators.** Fowler. 8d.

3981. **Driving electrically propelled vehicles.** Hopkinson. 8d.

4489. **Holders for electrical glow lamps.** Lauckert and Haensel. 8d.

4593. **Electrical batteries.** Rawson and White. 8d.

6400. **Electrical signalling apparatus.** Dingle. 8d.

7696. **Portable incandescent electric safety lamp.** Coal. 8d.

17,905. **Rotary dynamometer.** Kasalovsky. 6d.

18,057. **Electric lamps.** Justice. (Heisler.) 8d.

18,715. **Telephones, &c.** Smith. 6d.

18,900. **Electric telegraphy.** Dewey. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	19
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
26 April	4/0	Reuter's	8	7½
......	...	Swan United	3½	3
12 July	12/0	Telegraph Construction	12	35½
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15½

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NOTES.

Edison.—It is said that Edison is coming to Europe this summer.

Finland.—A long-distance telephone of 113 miles has been established in Finland.

St. Olave's.—The District Board of Works has resolved to take no action with regard to the electric light.

Shepton Mallet.—The Anglo-Bavarian Brewery at Shepton Mallet is now lighted throughout by electricity.

Rotherhithe.—The Vestry has resolved to consent to the provisional order of the Electric Supply Corporation, subject to certain objections being allowed.

South African Cables.—It is stated that the ships with the new West Coast extension cables will sail on March 8. When the lines are completed, this will give an alternative route to the Cape.

Indo-European.—The Indo-European Telegraph Company, Limited, announce that the Odessa-Constantinople cable is now repaired, thus restoring direct telegraphic communication with Constantinople and all parts of Turkey, "*via* Indo."

Society of Arts.—The paper to be read on Wednesday next, the thirteenth ordinary meeting of the session, is entitled "Arc Lamps and their Mechanism," by Prof. Silvanus P. Thompson, when Mr. W. H. Preece, F.R.S., will take the chair.

Melbourne Exhibition.—We are pleased to state that a first award, which is equal honour to a gold medal in this country, has been given to Messrs. Woodhouse and Rawson for their exhibit of electrical apparatus at the Melbourne Exhibition.

The Belgian Cables.—By order of the Belgian Government, engineers are thoroughly examining the old submarine cables between Belgium and England, in order to ascertain whether it is worth while to continue working them or whether new cables must be laid.

Melting the Ice by Electricity.—A new method of melting the ice and snow from the rails of tramways and railways is proposed by Mr. Ries, which, he thinks, will obviate both the slipping of wheels and the use of salt slush. This is to send a large current of low potential, and heat the rails sufficient to melt the ice.

The Director-General of Telegraphs.—The *Englishman* says that Sir Albert J. Leppoc-Cappel, Director-General of Telegraphs in India, has joined the firm of Pender and Company as a director. What is Pender and Company? Probably the Eastern Telegraph Company is meant, says the *Indian Engineer*, and the shareholders would hardly like the new name.

Institution of Electrical Engineers.—A students' meeting was held on Friday, February 22nd, at 8 p.m., Mr. J. Rance, jun., A.I.E.E., in the chair, when a paper was read, entitled "Ship Lighting and the aspects of Electrical Industries in the Colonies," by Mr. H. W. Handcock. The paper occupied the whole evening. A discussion upon the paper will take place on Friday, March 8th.

Bath.—It is rumoured that instead of the purely external or street lighting, that has been for some time under consideration, or rather in the act of being carried out, the good people of Bath have decided to extend the lighting, and provide for interior lighting by incandescent lamps. We have always contended that the mixed system was necessary for general lighting—the arc lights for open, and the incandescent for closed spaces.

North London Tramways.—At a rather stormy ordinary meeting, on Tuesday, of this company, the chairman of the company, in the course of his reply to some remarks, said that he hoped eventually electric cars would be adopted and that this would eventuate a dividend. It is assuring when we find directorates looking into this question of electric traction, and we hope that the surmise of Mr Carruthers Wain will be found to be correct.

New Cables.—The Eastern Extension, etc., Telegraph Company notify that the laying of their new cable between Java and Western Australia is now completed, and the line will be shortly opened for traffic. This will give the Australasian colonies the advantage of a third cable to Java, and an alternative land system *via* Perth to the overland line between Port Darwin and Adelaide, thus greatly adding to the security of telegraphic communication with Australasia.

Sweden.—Electric light and power are going ahead in Sweden. Last December a new electric light station for 3,000 16-c.p. lamps was opened in Stockholm, and now several other towns have adopted the light in their streets, among others Eskilstima and Lulea, this latter being the most northern town with the new method of lighting. An electric tramway is to be constructed at Sundswall, the motive-force being obtained from a waterfall a short distance from the town. This is the first trial of electric traction in Sweden.

Sheffield.—The central station at Sheffield consists of three 50-light Thomson-Houston machines, from which at present 110 arc lights are run. The plant has lately been increased by a Mordey alternator for distribution of incandescent lamps, which is to be started this week. This is for 600 16-c.p. lamps, and nearly the whole number are now taken up, so that the plant will have to be again increased. We are glad to learn that Mr. Tasker, the managing director, contemplates the introduction at an early date on the arc circuits of motors for supply of power.

Electrical Brakes.—The following details are given of the electrical brake of Widdifield and Button, which was tried on a heavy train on the Lehigh Valley Railroad last month. The train consisted of an eight-wheel locomotive, fifteen covered waggons, and two special carriages. Neither the special carriages nor the locomotives were braked when going from 36 to 40 miles an hour. The train was stopped at 28 seconds, after having passed over between 220 and 230 yards. This was the sharpest pull up—the ordinary stoppages for that velocity taking about 34 seconds, and the distance passed over being about 450 yards.

Sale by Auction.—As will be seen from our advertisement columns Messrs. Wheatley Kirk, Price, and Goulty will sell, on March 13, by order of the liquidators of the Electric "Sun" Lamp and Power Company, Limited, the entire contents of this company's works, which are situated at 5, Bombay-street, Bermondsey, S.E. Catalogues may be obtained of the auctioneers at their offices, 52, Queen Victoria-street. A sale is also announced through the medium of our advertisement columns of the patents, properties, and effects of the Elieson Electric Company, Limited. The date of the sale will be duly advertised.

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Paris.—The *Daily News* correspondent says: "The Town Council of Paris offers a prize of £400 to the inventor of the most reliable system of computing the quantities of electric light used, and five other prizes of £50. If any system is only applicable to a continuous or to an alternate current, half the money offered will be given. The city of Paris will consider itself entitled to the full ownership of all the inventions which may gain prizes." The amount offered is not worth the consideration of anyone possessing a good meter. If such prizes as these are offered, they should be sufficiently valuable to repay the inventor. If the ownership was restricted to the city of Paris the case would be different, but as we read the communication, the inventor of the best meter gives his invention absolutely to the city, and gets in return £80, £200, or £400. We prefer to keep the meter.

Books Received.—"Practical Treatise on Industrial Electricity," including a description of Units and Measures, Batteries and Electrical Machines, Electric Lighting, Transmission of Energy and Electro-Plating, and Electro-Metallurgy and Telephony. By Messrs. E. Cadiat and L. Dubost. Third edition. Illustrated with 264 engravings. Published by Baudry and Co., 15, Rue des Saints-Pères. In regard to this book the authors say in the preface, that they have from the commencement endeavoured to render this treatise of an essentially practical character, and have eliminated all those considerations which are purely abstract. Following this programme, the third edition has been remodified in many instances, in order to retain this special feature of the work.—"Glimpses of Feverland, or a Cruise in West African Waters." By Archer P. Crouch, B.A. (Oxon), author of "On a Surf-Bound Coast." London: Sampson Low, Marston and Co.

Anglo-French Cables.—M. de Fonvielle, says the *Times* correspondent, in a forthcoming article in *Electricité*, explains the question of Anglo-French cables. The English Government had agreed to purchase them at valuation, but on the representation of France tests of conductibility and insulation were resolved upon, which terminated on Friday. The English experts applied five-minute tests, and found the cables to be in good condition, but the French experts made 15-minute tests. The results of these were much less favourable, and England has agreed to adopt this system. The price is likely, therefore, to be considerably reduced. The Dover and Calais cable is the only one in a satisfactory state. The Folkestone and Boulogne cable is unserviceable, and the other cables have several wires out of order. The reduction of the rate from 2½d. to 2d. per word will commence on April 1. M. de Fonvielle points out that the traffic last year, 13,000,000 words, is almost precisely the same as that of the French cables to Africa, which have the scarcely remunerative rate of one penny per word.

Morecambe.—Messrs. Andrews and Preece, of Bradford, have issued notices of their intention to apply to the Board of Trade for a provisional order to supply electricity for lighting purposes in Morecambe. They stated, at last week's meeting of the Local Board, that in the event of the Board not opposing their application they would fit up a central station, lay all wires underground, and supply the electric light for ordinary domestic purposes at a charge of 7d. per unit, equivalent in price to ordinary gas at 4s. per 1,000ft. For public lighting they were prepared to supply 12 2,000-c.p. arc lamps, 100 yards apart, and at an elevation of 35ft. from the ground, for £25 per lamp per annum; or for 100 nights during the season at £10 per lamp, being 10s. each lamp per night. Six lamps for the same period would cost £11 each. In winter they could substitute incandescent lamps for street lighting at the same price as for domestic purposes, the expense of a 32-candle lamp of that description being estimated at from 28s. to 30s. per year; the cost of inside fittings to be borne by the householder or owner, as in the case of gas-fittings.

The London Telegraph Clerks.—Two well-attended meetings of the clerks of the Central Telegraph Office, London, have been held, at which great dissatisfaction was expressed at the stagnation of promotion. From the statement of facts made by various speakers, it was evident that the crisis had become very serious, and was without parallel since the threatened general strike of telegraphists in 1881. At each meeting a resolution was passed pledging the London telegraphists to take combined action with their provincial brethren, and it was announced that efforts would be made to bring the grievances of the service under the notice of Parliament. It would be well, perhaps, if the telegraphists would learn a lesson. Promotion cannot be made to suit their fancies. The higher positions will neither be vacated by death nor compulsory retirement to find posts that the stream of promotion may be continuous. No doubt the telegraphists have their troubles, but in this case the cause is envy rather than anything else. The Government servant is a peculiar specimen of the *genus homo*. He fights like wildfire to get his appointment, and directly he gets it begins to grumble because it is not good enough.

Metropolitan Railway and Electricity.—On Wednesday a special general meeting of the proprietors of the Metropolitan Railway Company was held at 32, Westbourne-terrace, Paddington. Sir E W. Watkin, chairman of the company, presided, and observed that the meeting was called for the purpose of approving or disapproving two Bills proposed to be introduced to Parliament. One was promoted by the company, and the other by a friendly company. The Bill to be introduced by the Metropolitan Railway Company empowered the company to take a small piece of land for the Aylesbury extension railway, and to make a short railway, seven furlongs and one chain in length, to Chesham. The Bill authorised the Metropolitan Railway Company to run over the Aylesbury and Buckingham Railway line, and to use electricity in addition to other motive powers. The Bill promoted by the Worcester and Broom Railway Company enabled that company to construct a railway from Moreton Pinkney to Aylesbury, where the new railway will form a junction with the Aylesbury and Buckingham Railway. Resolutions approving the two Bills were carried, with power to the directors to make any alterations necessary.

Halifax.—At the last ordinary meeting of the Halifax Town Council, says the *Halifax Courier*, communications were read from Messrs. M. Holroyd Smith, England and Foster, Blakey, Emmott and Co., and J. R. Smith with respect to the establishment of the electric light in Halifax. Messrs. Blakey, Emmott and Co. asked permission to carry cables overhead or underground for the purpose of the supply. Messrs. England and Foster, writing on behalf of an intended company, to be called the Halifax Mutual Electric Light and Power Co., sought permission to take overhead wires to the various shopkeepers and across the

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following streets: Broad-street, Corporation-street, Silver-street, Crown-street, Princess-street, Crossley-street, North-gate, Market-street, Southgate, and Harrison-road. The communications were referred to the Mayor (Alderman Jas. Booth), Aldermen Midgley and Pollard, and Councillors Davis, Bairstow, Binns, Oddie, Uttley, and Brear. This special committee met on Monday evening and passed the following resolution: "That permission be granted to fix wires overhead for the supply of electric light, the area and other details to be submitted by the undertakers to the Corporation for approval, the Corporation to be at liberty to purchase the plant at the end of the first seven years, or at the end of every succeeding seven years."

Better Late than Never.—The gas folks at Liverpool are bestirring themselves. One of their organs says: "However, the company are about to encounter a somewhat severe opposition in the shape of the introduction of the electric light for lighting purposes in Liverpool. To counteract this breach in their monopoly the company express their intention of conducting their works in an economic manner, and at the same time endeavour to supply cheap but good gas to the public. This, there is no doubt, is a wise resolution, and it is hoped will be thoroughly carried out, for if the public get a cheap and good gas light, they will not seek after a new and uncertain method of illumination. The chairman of the company stated to the shareholders that the consumption during the past half-year had been greater than it had been during the corresponding period of last year. It may be said for the satisfaction of those holders of shares in this particular company that although the electric light will no doubt be tried as a means of illuminating the streets of Liverpool, it will be a very, very long time, if at all, before it is extensively used for domestic services. As one speaker put it, there is plenty of room for both kinds of lights, the electric light being used as a luxury." Are we to understand from this that hitherto the works have *not* "been conducted in an economic manner"? Does this laxity prevail in many gas works? In other words, have they been conducted carelessly and uneconomically because the profits were so large that attention to details "did not matter."

Domestic Lighting.—Under the heading of "Domestic Electric Lighting in London," the *Financial News* of Monday last has a leader, the introduction of which is as follows: "A burned child dreads the fire, and the public who lost their money in the premature electric lighting boom of 1882 are rather sceptical of the financial promise of the revival which has now set in. But the collapse of the Brush mania was due to inherent engineering difficulties which have since been surmounted, and the business of electric light supply now rests upon a safe commercial basis. The recent opening of the House-to-House Company's Kensington central station, which was designed by the founders of the central station system, was looked forward to electrical circles with unusual interest. The station has been executed entirely by the House-to-House Company's own engineers, and mainly on the strength of experience obtained at Eastbourne, which is the only place where electric lighting has been accomplished from one centre throughout an extended area by means of underground mains. It is the fulfilment of these conditions—namely, the illumination of a large area by means of underground mains, as required by the permanent form of tenure under the Electric Lighting Act—which invests these installations with exceptional interest, and it is generally admitted that the Kensington station is one of the most perfect of its kind in the world. The central stations in Rome and Philadelphia are held to compare with it in excellence, and a paper instituting a comparison between these works is to be read at the Institution of Electrical Engineers at an early date."

Ohm.—In our issue of February 8th we referred to the appointment of a committee to promote the erection of a statue to Ohm. We are glad to see the *Daily News* supporting the movement as follows: "Electricians and physicists in general will be glad to hear that a committee has been formed by members of the Royal Society to assist the Munich committee in the erection of a statue to George Simon Ohm. The fundamental law so well known by the name of Ohm's law is familiar to the beginner in the study of electricity, but comparatively few advanced students know much about its discoverer. Born at Erlangen in 1789, he was in his earliest youth introduced to the mysteries of mathematical science by his father, an intelligent and self-taught blacksmith. Following up this early training, young Ohm started on his career as a teacher of mathematics and physics. He filled several educational posts, but it was not until after many years that he was appointed to a post at all proportioned to his merits. This was the professorship and rectorship of the Nürnberg Polytechnic School. In his sixty-first year he was appointed a professor in the University of Munich, where a statue is to be erected to mark the centenary of his birth. Prof. Carey Foster and Prof. John Perry are acting as secretaries in England to receive subscriptions, while Lord Rayleigh presides over the committee of the Royal Society. It is eminently fitting that some of the countrymen of Faraday and Sir William Thomson should join in this design of doing tardy honour to the memory of a great discoverer, who laid the foundations of the precise science of electricity."

The Strand.—At the last meeting of the District Board of Works, the Lighting Committee submitted a long report dealing with the electric lighting, and in the first place recommended that the application for provisional orders for same by the Electrical Power Storage Company, and also on behalf of Mr. Koeher, be not entertained. The report continued by stating that, from the number of similar applications received, it was apparent that the question of electric lighting had reached a practical stage, and had assumed more serious and immediate importance than in any previous years. The draft provisional orders as applied for were open to serious objections, they being drawn principally in the interests of the companies, and containing no effectual process for securing an adequate and continuous supply of light, and insufficient provision whereby such light could be enforced. Under their clauses considerable interference would take place in the streets, and the obligations for supply were illusory. In response to application made by the committee, the Metropolitan Electric Supply Company intimated that they recognised the importance of the objections made on behalf of the district, and that they were willing to adopt any such form of agreement as would afford a solution to the question of electric lighting and be satisfactory to consumers. The committee drew up an agreement in those terms to the last-named company, and recommended it to the Board for adoption. The agreement limited the interference with the thoroughfares to the pavements or the roadway near the pavements, and secured that that interference should be made at convenient times.

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The recommendation, after a few remarks, was agreed to, the adoption being moved by Mr. Warne.

Bradford.—Those of our readers who know Bradford will remember the Midland Railway Station. The Bradford Corporation's central electric lighting station is situated on what was a piece of waste ground near here, a little way down the road to the left. It is a handsome solid stone building, with boiler-house and chimney shaft adjoining. The whole of the machinery is being prepared by Messrs. Siemens Bros., and the foundations are ready to receive the engines, which will be delivered shortly. The supply being undertaken by the Corporation, they will not be able, nor do they wish, to pick and choose their customers. All comers will be supplied, and current only—or rather electric energy—will be charged for; the consumers will be able to use the current in any way they please inside their buildings for light, heat, power, or for charging accumulators. Full and continued tests will be made to settle upon a reliable meter. This service necessitates a direct-current system, and this will be adhered to in all extensions of the system, and will enable the subsidiary stations to be linked together. The mains will all be laid underground. A low-tension system will be adopted at first, and the mains will vary in pressure to compensate for loss by resistance, to bring the distributing wires to the same pressure. As the demand increases, high-pressure mains may be laid to outlying districts, with battery or other practical means of direct-current transformers. The electrical work is not in a forward enough state for much to be said at present, and it is probable, when this is the case, that details will be communicated to the Institution by Mr. J. N. Shoolbred, consulting engineer to the Corporation.

Deptford.—On Wednesday evening, the 20th ult., a meeting was held, under the presidency of Mr. E. J. Wright, at Deptford, to consider the question of the supply of electricity in the district. There was a fairly good attendance. The chairman said that the Electric Supply Corporation had erected works at Deptford, and were applying for a provisional order from the Board of Trade, the question of which will come before the Greenwich Board of Works at the next meeting. Mr. Sparkes, one of the engineers of the company, delivered a statement as to what the company are able to do. He said the electric wires would be in pipes, something like gas pipes, and there would be a wire into the house, and a meter, and the occupier would be able to use the electricity for motive power or for lighting. The company, however, would have nothing to do inside the house. They were makers of the electricity, and nothing more, and had no desire to become a monopoly. They did not propose to supply lighting for the streets unless it was asked for. The cost to have one light would be about 45s., but the company did not supply for less than 25 lights, with a minimum charge of £20, but when they started at Deptford they would probably be able to reduce this minimum, and hoped in time to bring the price below that of gas. After some discussion, in which the chief topic was the disturbance of the roads, it was resolved: "That whilst approving in principle of the extension of electric lighting, to ask the Greenwich Board of Works to deal with the issuing of a provisional order in such a sense as to prevent monopoly, and avoid undue disturbance to the highways of the district, to guard the interests of the ratepayers in regard to prices and profits, and to provide for the compulsory supply of electricity by the company to the ratepayers on fair and reasonable terms."

Electric Stamp.—A company has been formed during the week to manufacture, and sell or hire, the Electric Time and Date Stamp, to which we referred a few weeks ago. It is believed that this stamp will be very useful in many offices, where the time of receiving goods, or sending out letters or parcels, is of importance, or in such cases as the time of the despatch of trains, tramcars, and omnibuses, or of the despatch of messages. The stamp was originally invented for dating telegrams, and for this purpose, if it can be made thoroughly reliable in its clock action, it should prove extremely advantageous. The electric stamp has been tested by the Post Office authorities, and an order for stamps to suit this purpose has been given. Some of the tramway companies have also tried them and express satisfaction with the result, giving orders for stamps for use on their lines. With a simple electrical connection, these stamps might be used so that trains might automatically register the time of passing upon a record strip in the signalman's office; and a similar electrical arrangement could be adopted for night watchmen, policemen, and others, where the time of their presence is of importance. In substance, the electric stamp is a small box with a lever handle on top for giving a blow on the paper to be stamped. Inside is simply a series of wheels properly geared, having on their circumferences figures to represent the hours, days, and minutes. These are moved forward with a step-by-step action by an electromagnet. The magnet is excited by a current from a battery, the circuit of which is closed once every minute by contacts on a clock. One clock can control a series of stamps, or a series of clocks can be controlled from one master clock, as desired. There is little doubt that the stamp may prove very useful in the departments for which it is designed.

The London Vestries.—The Committee of Works reported, at the last meeting of the Holborn District Board, that they had had under consideration the applications of the London Electric Supply Corporation and the Metropolitan Electric Supply Company for permission to apply to the Board of Trade for provisional orders. They recommended that permission be given. The report was adopted. Permission was also given to the House-to-House Electric Light Supply Company to apply to the Board of Trade for a license to erect works and supply electricity within portions of the district.—The Kensington Vestry has received the following communication from the Kensington Electric Lighting Company: "Your attention has no doubt been called to the fact that we are making arrangements to fix some arc lamps along the portions of the main road between De Vere-gardens and Queen's-gate, which is lit on one side by the Westminster Vestry. If this work is carried out, we would like to suggest that to make the trial more complete, and for the information of the Vestry, it would be a good thing to light some lamps in your district as well. If the Vestry approve of this proposal, we shall be glad to go into full details with you in conjunction with the Westminster Vestry. The arrangement we are making is that the work shall be done and the light supplied for a period of one month free of charge. If at the end of that time the Vestry wish to have either the lamps in question continued or other lamps supplied, we will then be in a position to give an exact estimate of the cost of fixing and supplying. The Vestry would not be bound to continue the lighting after the end of the trial." It was resolved that the offer be accepted, the work to be carried out to the satisfaction of

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the surveyor.—St. Martin's-in-the Field's Vestry has passed a resolution approving the application of the London Electric Supply Company for a provisional order.

The City Lighting.—At a special meeting of the City Commission of Sewers on Tuesday at Guildhall, the Streets Committee reported the conditions upon which proposals for lighting by electricity should be advertised for. The main thoroughfares and public streets of the entire area of the City are to be lighted, and for convenience divided into three districts, and the contractors are at liberty to tender for either one or two districts, or the whole City. The three districts are denominated the west, the central and the east, and the positions of the arc and glow lamps, as well as those of the existing gas lamps, are to be expressly indicated, and, in addition, the positions of the mains and service pipes. So soon as the main thoroughfares have been lighted, the contractor must proceed, when called upon, to light the other public ways. The whole of the lamps are to be efficiently lighted nightly from sunset to sunrise, and when otherwise necessary; but the existing system of gas lighting is in no way to be interfered with, in case gas lamps may have to be reverted to. All mains and service conductors are to be laid beneath the public way, and in no case are streets to be broken up without notice, or telegraph and telephone wires interfered with. So far as the Commission are able to do so, they will grant to the contractor the exclusive right of supplying electricity for private purposes within the district, and the consumers are to be charged either by meter or agreement at a fixed rate. The duration of the contract is to be 21 years, subject to determination in certain contingencies, and it is provided that if the profits arising from the contract exceed a cumulative dividend of 10 per cent. per annum on the capital invested, the excess is to be divided equally between the contractor and consumer by the reduction of the charges. Power is reserved to the Commissioners to acquire the undertaking and works by purchase at the end of 21 years. After some discussion the adoption of the report was carried by a large majority, and the conditions of tendering were approved.

Electric Blow-Pipe.—A new method of electric welding, or electric blowpipe, as it may be termed, is proposed by Prof. Sheldon, of Harvard, in the *Scientific American.* The peculiar behaviour of the arc in a magnetic field is employed in this process. A dynamic attraction or repulsion occurs when a pole of a magnet is brought near an arc light, and the arc is apparently blown outwards in the form of a flame, terminating in an intensely luminous point. The heat at this point is intense, and suffices to melt any metal. A piece of No. 14 copper wire held at the apex melts instantly. This extreme heat in such a convenient form can be the means of bringing electro welding within the reach of all shops where arc lamps are employed for illumination. By a mere nominal alteration the lamp may be made to perform the double function of illumination and welding. To attain this end, a straight electro-magnet wound with coarse wire is only necessary. This is placed with one end towards the arc, and may be fixed in one position (to be determined by experiment, and depending upon the direction of the desired point of the arc), or made movable in a horizontal plane on a level with the arc. The two terminals of the magnet coil are inserted anywhere in the main circuit, or, if found necessary, may be shunted from the same. The connections once made, can remain undisturbed, and, without influencing the main line, the lamp performs its two functions. In the employment of the arc for electro welding, the operator must, of course, wear coloured glasses for the protection of the eyes. Care must be used in the selection of these, for some of the colouring matter used (especially in blue and red glasses) absorbs the light given out at the apex of the arc, and this would be detrimental to fine work. The electric arc, when in a strong magnetic field, exhibits another peculiarity. It is known that if a circuit, traversed by a strong current, be broken under ordinary circumstances, a moderate spark will ensue, accompanied by a snap similar to that given by a toy cap when exploded. If, however, the break be made in a strong magnetic field, an extremely large spark follows, accompanied by a peculiarly sibilant report, as intense as that of a pistol. The effect is very startling when unexpectedly made.

Manchester.—The proposal to establish a central electric light station in Manchester is now, we believe, well within view of possibility. The gas works of Manchester, it may be remembered, are owned by the Corporation, and this fact naturally causes complex views of the new proposal on the part of the members of the Corporation. The Manchester Edison-Swan Company were open to obtain a provisional order for themselves, but they judged it to be wiser to endeavour to work with the Council. On the proposal being submitted, the Corporation signified that they must have assurance that a demand really existed for the electric light, and stipulated that signed requests for a supply of 8,000 incandescent lamps must first be obtained. A canvass of the proposed district has therefore been made, with very encouraging results. Up to the present, the company have received requests for some 7,000 lamps, with numerous others in blank not committing the persons to the number required—making, probably, a total of some 10,000 or so. When the canvass is finished, these signatures will be submitted to the Corporation, who then, it is hoped, will work together with the proposers of the new light. A fresh call on the shareholders, to the extent of £2 a share as required, would be made for the purpose of carrying on this work. The area proposed to be lighted is the busiest centre of the town, and, as land is expensive here, the station would not be directly in this district, but some little distance away. The system, as far as has been arranged, will be the alternating transformer system, with underground mains. Estimates have been gone into by the company to ascertain the approximate cost, but nothing absolutely definite is yet arranged. The station would be at first for 10,000 lights, one would be extended, or similar ones established in other parts of the town. The scheme has been started and would be carried out by the Manchester Edison-Swan Company. The company of the name of the Manchester Electric Supply Company have nothing to do with the proposed station (as has sometimes been thought), being at present simply the branch office of Messrs. Holmes and Vaudrey, of Liverpool. This will be the first practical attempt of the Manchester Edison-Swan Company to distribute electricity on any scale. The small station with accumulators once established there, was for the theatre alone, and this has been discontinued for some time, leaving the entire work of the company to consist at present of house and factory installations, of which a very large amount has been done in the district. We shall await with interest the result of their present action in promoting a central station for Manchester.

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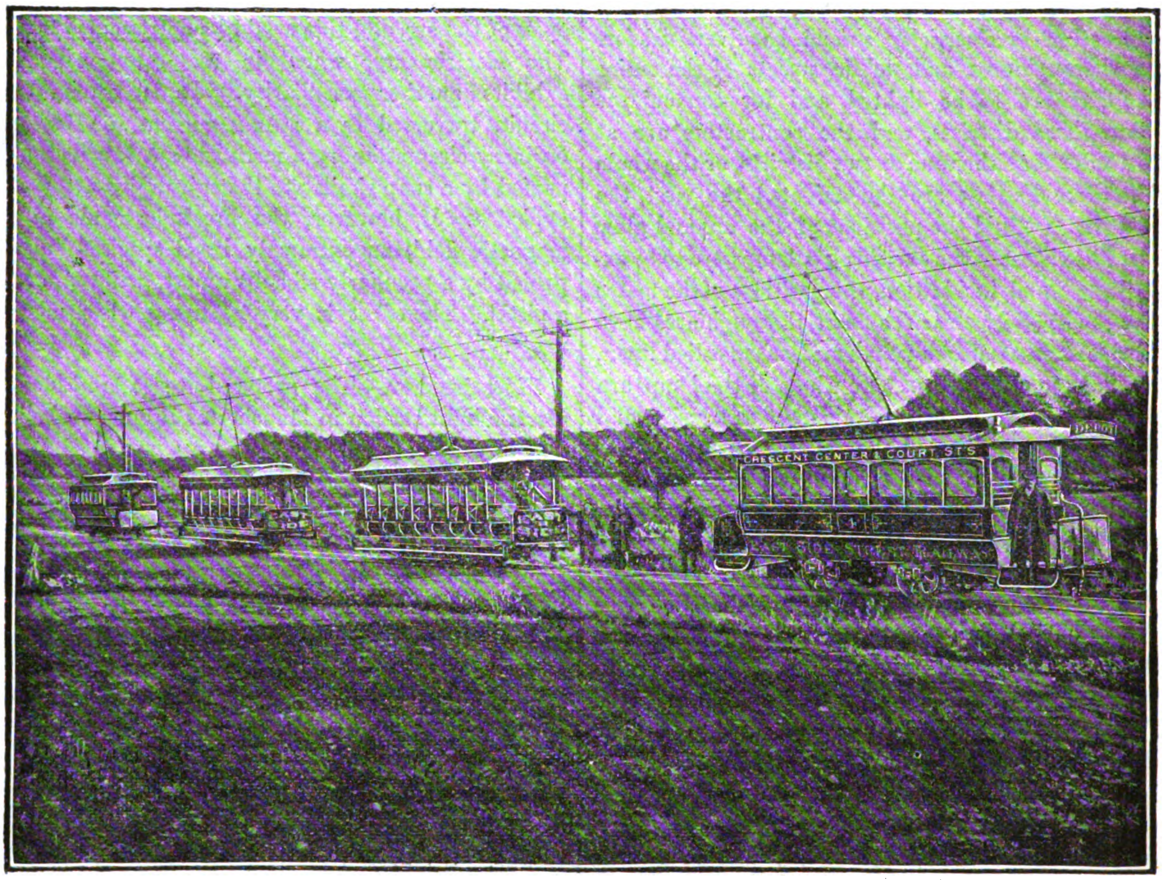
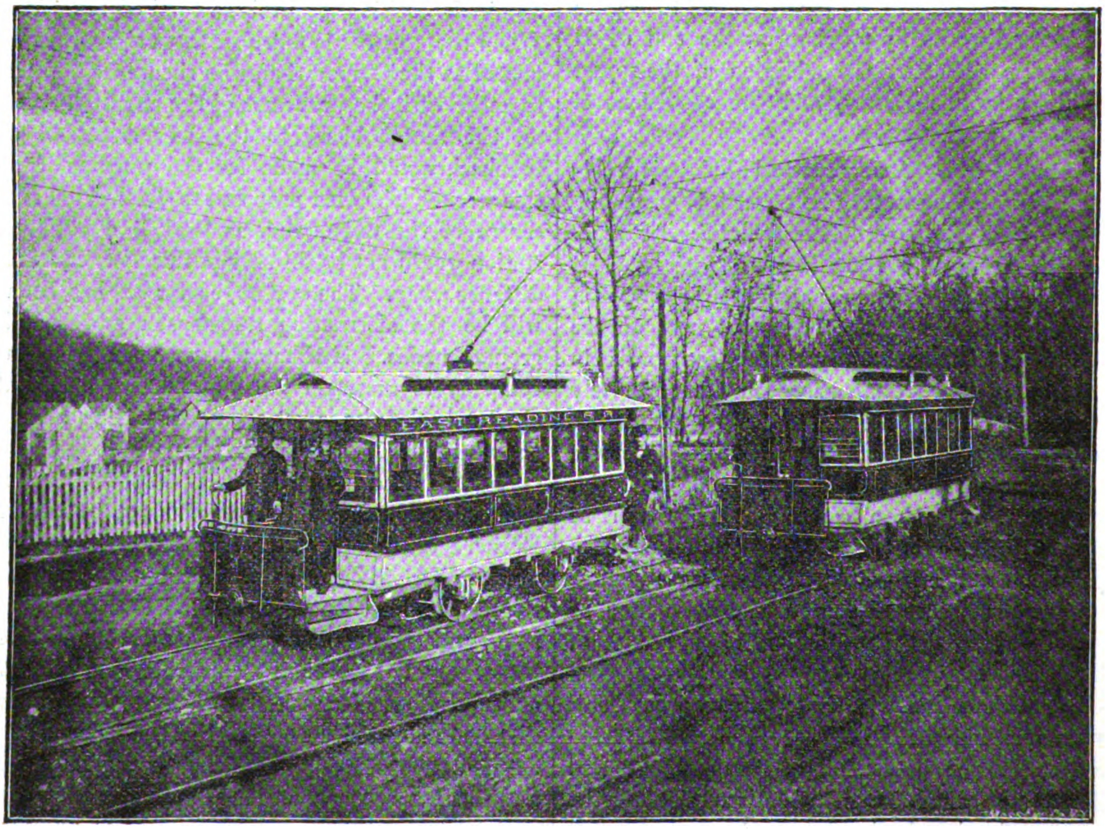
ELECTRIC TRACTION IN AMERICA.

THE SPRAGUE SYSTEM AT BROCKTON, READING, AND WILMINGTON.

While we in England are laboriously talking about introducing electric traction in various directions, our American cousins are engaged in less talking and quicker action. A short time since we received further information as to the later doings of the Sprague Company in various parts of America, and we notice that our American contemporary, the *Electrical World*, has been also discussing this subject. The illustrations which we give herewith, and for which we are indebted to the Sprague Company, show several views taken from recent photographs of electric railways which have been installed by this company.



I.—Sprague Electric Railway at Brockton. Bunching the Cars.



III.—Sprague Electric Railway. Reading, Pa.

The first two engravings are of views on the East Side Electric Railway of Brockton, Mass., of which Mr. Albert F. Small is president. This road extends over a circuit of

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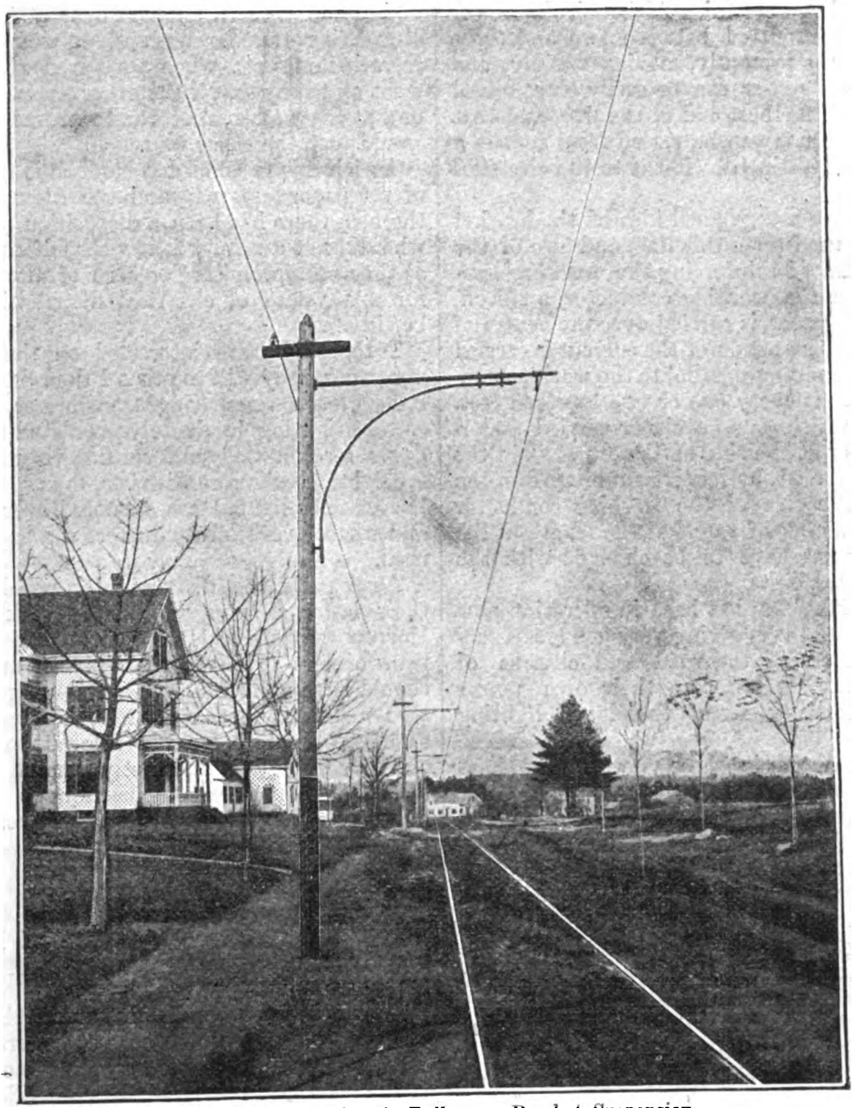
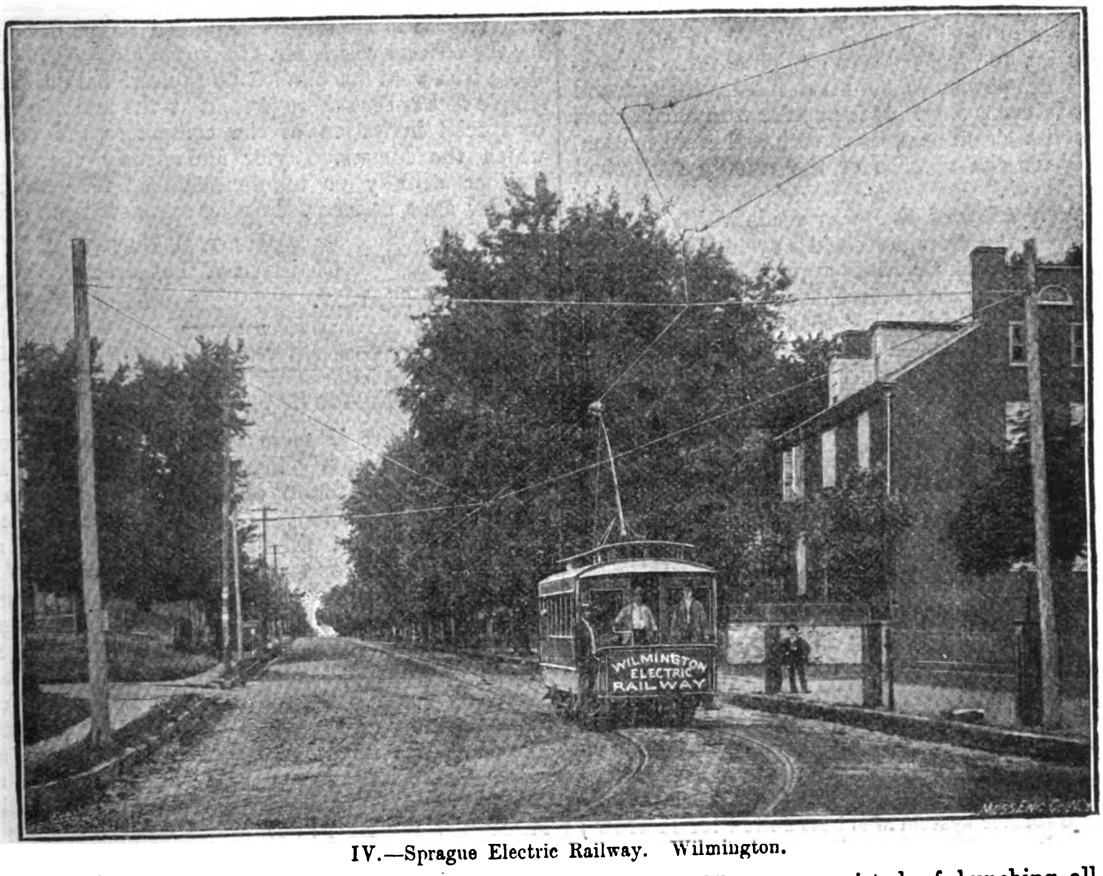


II.—Sprague Electric Railway. Bracket Suspension.



IV.—Sprague Electric Railway. Wilmington.

about four miles in length, operating four cars. The first engraving represents a test which was recently made upon the railroad, and was taken from a photograph made upon the spot. The test consisted of bunching all the cars of the company at a point on the road farthest distant from the power-house, and in starting them all up at once.

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The test was perfectly successful. Although the power for all the cars was transmitted between two and three miles, the cars started up promptly, moving rapidly, and showing that the entire power can be easily transmitted and applied even at the farthest end of the line, and that the load upon the dynamos can be varied from zero to a maximum without any resulting detriment to the electrical apparatus.

The second view gives a very good idea of the bracket method of suspension used upon this line, and also of the Sprague overhead system of reinforcing the working conductor. By this system the working conductor, a silicon-bronze wire of small diameter, is carried over the centre of the track, while the greater portion of the current is carried upon a main conductor running parallel to the working conductor, and connected to it every one or two hundred feet. This main conductor, which can be either carried underground in a subway, or at the side of the street as in the view, can also be reinforced by feeders running from the main power station. The size of the working conductor is independent of the number of cars and the length of the line, and therefore does not have to be changed with the alteration of any of these points.

This electric road at Brockton has been in operation now for about four months, and it is giving very good satisfaction to both the directors of the road and citizens of Brockton. The company do not own their own power station, but hire electricity from the local lighting company.

The second road illustrated in these views is the East Reading Railway, of Reading, Pa. This view gives a very good idea of the method of overhead wiring for a turn-out. The road is a single track road, extending over about two miles, and is said to be giving very good satisfaction to the president and directors of the road. The road has been in operation about two months.

The fourth engraving is a view of an electric car on the Wilmington City Railway, which has been in operation upon the Sprague system for about eight months. This road has given such great satisfaction that the directors of the road have ordered an additional number of cars.

In the letter to the Sprague Company, the president of the road, Mr. William Canby, says: "From the practical experience we pronounce your system a complete success. We consider it by all odds the most economical mode of running street cars in suburban districts, or in any place where permission to erect poles can be obtained. In comparison with horse-power, we find it decidedly cheaper and more efficient in every way. It is popular with our patrons on account of its cleanliness, its smooth and rapid motion, and especially for the absence of the usually overtasked and labouring horse."

These are only a few of the many roads which are now in operation upon the Sprague electric system in all parts of America. The number of Sprague electric roads is rapidly increasing, new contracts being closed every day, one of the latest of which being that for Atlantic City, New Jersey, made by the Pennsylvania Railroad Company, who own the system of railways in that city.

CORRESPONDENCE.

HARROW LIGHTING.

To the Editor of The Electrical Engineer.

Sir,—The form of your report on the meeting held at Harrow would lead your readers to suppose that it was absolutely verbatim, at any rate sufficiently so to correctly represent what passed at the meeting. I find, however, on reading it over, that there are important omissions. For instance, after stating that I explained the two well-known methods of distributing electricity by alternating transformers and by battery transformers, I am made to say simply that the former system was best suited for Harrow; whereas I took considerable pains to point out that, although as a rule I had a preference for the battery transformer system, yet on account of the peculiar distribution of the Harrow lighting in a small number of large houses distributed over a considerable area, the alternating transformer system was at its very best, as regards first cost, when compared with the other; but I went on to say that if the other site which had been pointed out at the west end of the town was adopted, the balance would turn the other way.

I wish this to be clearly understood, as since the reading of my paper last year, and the discussion which followed thereon, there has been a disposition on the part of those who did not carefully follow that discussion to consider me as the uncompromising opposer of alternating transformers for any system of electrical distribution, wherever it may be situated.

If those who are interested on the subject will turn to my paper, they will see that I then dealt with the unsuitability of the alternating transformer system for central station lighting in densely-populated towns—such as London. I acknowledged from the very first its great utility for lighting suburban districts, towns, or villages, where the houses to be lighted are scattered over a considerable area, and where overhead conductors can be wholly or partially used.

As regards the discrepancies which Messrs. Taylor, in their letter to you, appear to think exist between my Harrow estimate and the general estimate for alternating transformers given in the body of my paper last year, I should have no difficulty in reconciling the figures to those who understand such matters, bearing in mind that the smaller estimate is for 144 kilowatt plant only, and that the very important and costly item of boilers, water-tanks, feed supply, and steam connections is omitted, as we were informed that these could be taken over on rental from the water works company.—Yours, etc.,

R. E. Crompton.

ELECTRIC LIGHTING IN HARROW.

To the Editor of The Electrical Engineer.

Sir,—Mr. Crompton is doubtless well able to defend his position as against the attacks of Messrs. Taylor.

I believe those gentlemen were the only persons present at the meeting at Harrow who regarded Mr. Crompton's clear and business-like statements as a "fiasco." Be that as it may, I can neither take to myself the blame which they impute to me for the supposed fiasco, nor the credit for the success which Mr. Crompton attained in the eyes of those who were not blinded by professional jealousy. The simple fact is that those present at the meeting were there by special invitation of the committee, the existence of which the Messrs. Taylor audaciously charge me with "either wilfully or unintentionally" forgetting, and of which I am a member. Further comment is unnecessary.—Yours, etc.,

Robt. B. Hayward,
Chairman of the Harrow Local Board.

February 26, 1889.

UNDERGROUND MAINS.

To the Editor of the Electrical Engineer.

Sir,—As there is some misapprehension caused by an advertisement recently inserted in your paper as to the West Brompton station of the House-to-House Electric Supply Company, Limited (called by them the Kensington station), I trust you will allow me, on behalf of my company, the Kensington and Knightsbridge Electric Lighting Company, Limited, to furnish you with a statement of the work done by the respective companies in Kensington.

My company (the Kensington and Knightsbridge Electric Lighting Company, Limited) commenced in 1887 to supply electricity under a license from the Board of Trade in a limited area round the works situated at Kensington Court. The plant was furnished by Messrs. Crompton and Co., Limited, who acted as the engineers, and devised a system of underground mains which gives complete satisfaction. Thereupon my Board decided to enlarge their operations and apply for an extended area, a portion of which has since been granted. In consequence, electricity is now supplied through several mains at a radius of three-quarters of a mile, and in a short time the

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distance will be considerably extended. There will, however, be no necessity in this district to carry the current more than two miles, as the company have a station in a central position at Knightsbridge, which is now in course of completion.

From the mains already laid, shops, houses, and public buildings (including the St. Mary Abbotts parish church) have been supplied with the current night and day constantly with the utmost satisfaction.

As to the House-to-House Electric Supply Company, Limited, I am, after enquiring a fortnight since, in a position to state that in spite of all their protestations and advertisements, they have not to my knowledge supplied any current to houses or shops within the district of Kensington. Further, I am unable to see how they can claim to be the first company in London to supply an extended area through underground mains inasmuch as they possess no license from the Board of Trade to break up the streets. I trust you will insert this in your next issue, as my company is suffering from the confusion which has arisen from the House-to-House Electric Supply Company adopting the name of the "Kensington Station" for their station at West Brompton, and making the claims above referred to.—Yours, etc.,

R. Erskine, Secretary.

High-street, Kensington, Feb. 28, 1889.

THE ELECTRIC LIGHT IN BARNET.

To the Editor of The Electrical Engineer.

Sir,—In pioneering the system of incandescence lamps in series for street lighting at High Barnet, we have had to contend with great opposition and unusual difficulties, but even taking into account the stoppage of the light owing to uncontrollable causes, such as wilful damage to our wires, etc., the whole of the failures during the past six months and severe winter weather has barely exceeded 1 per cent. of the total hours of lighting, and this we submit is very encouraging, and is, we believe, the best record of town lighting.

In the opinion of many qualified engineers who have visited Barnet, the system of street lighting by 32-c.p. incandescence lamps is a success.—Yours, etc.,

Henry F. Joel and Co.

City Electric Light Works, 31, Wilson-street, Finsbury, London, E.C., and Melbourne, Feb. 27, 1889.

RECENTLY PATENTED IMPROVEMENTS IN SECONDARY BATTERIES.

We are in receipt of the following interesting statement from President D. H. Bates, of the Electrical Accumulator Company: "The manufacture of secondary batteries in the United States is increasing rapidly with the growing demand for this form of apparatus in electric lighting and applications of power. The question as to whether or not the broad features of improvement attributed and patented to Faure are to be secured to his assignees, the Electrical Accumulator Company, is now in the hands of Judge Cox, and a decision will be rendered very shortly. The recent decision in the United States Supreme Court in the Bate refrigerating case has eliminated the only defence having any apparent merit. Faure's invention, as is well understood, was the application of an active material to a plate or support prior to immersion in the battery fluid. Subsequent inventors modified the nature and form of the support plate and the manner of combining this support plate and the active material. Among batteries now obtainable, whether at the hands of authorised manufacturers or infringers, are those having a support plate of lead, others having a support plate of lead and antimony with perhaps a little mercury added; and as regards the form of plate, the key-lock principle is applied to all. Perforations having a smaller diameter at or near the centre of the plate meet with the greatest success; others have cells or perforations, the greatest diameter being at points intermediate between the surfaces of the plate. Your patent record shows that the specific modifications mentioned were long since contemplated and patented by an English inventor.

"The result of the recent interference between the application of John S. Sellon, of Hatton-garden, England, and Edmond Julien, assignor to the Julien Electric Company, is shown by the issue to the Electrical Accumulator Company (Sellon's assignees) of patent No. 396,958, dated Janury 29, 1889, claim 2 being the issue in interference, to wit: 'In a secondary battery a plate, element, or support containing lead and antimony in combination with an active material.' Recent publications emanating from Julien's assignees give an impression widely at variance from the issue of this patent shows to be the facts. The language of the technical expert of the Patent Office, not referred to in the publication of the Julien Company, shows what the facts really are: 'If Sellon was the first to use plates formed of lead and antimony, or two or more metals, of which lead and antimony are essential, I can see no good reason why he should not claim his invention in such broad terms as would prevent its being pirated by the addition of a small percentage of some other metal. The addition of a small proportion of zinc, tin, or bismuth, all of which are well-known constituents of type metals, which are essentially alloys of lead and antimony, would avoid any patent he might obtain, unless he is protected by some such claim as the one in interference, and the purpose of the claim seems to be to protect him from just this danger. Julien's claim is included in and subordinated by the claim of Sellon, for the reason that it is directed to an alloy of which lead and antimony are essential ingredients.' The issue of this patent gives Sellon's assignees, the Electrical Accumulator Company, the control of the battery employing an alloy plate, whether the present suit based upon the Faure patent now in the judge's hands, and upon which a decision may be expected within a short time, is favourable or unfavourable. The public may therefore take warning at this time against further infringement on patented rights; for, if upon the decision being rendered against the manufacturers such manufacturer should be insolvent or irresponsible, resort will doubtless be had to consumers or users for an accounting and for damages.

"A second very important patent granted on the same date to the assignees of Sellon for improvements in secondary batteries, No. 396,770, is also of sufficient importance to merit special attention. This is intended to cover and covers a special form of perforated plate, such as is used by the Gibson Electric Company, and such as is shown in the recent modification of Faure's invention attributed to Anthony Reckenzaun. The Gibson battery makes more or less successful use of a perforated plate produced by piercing a sheet of lead with a series of perforations in such a manner that the openings at the surface of the plate are smaller than the diameter of the perforation at one or more points intermediate the surfaces. The claims of this patent, as will be seen from the example given, cover this construction. For instance: 'In a secondary battery a plate, element, or support, having cells, perforations, or receptacles, the diameter of which at or near one or both poles of the major axis is less than the diameter at one or more points intermediate said poles.' This gives the assignees of Sellon a practical control of the form of battery manufactured by the Gibson Company, the invention of Sellon, as shown by his English patent, having been perfected long before the construction was adopted by Gibson.

"The third patent covers the construction adopted by FitzGerald Jones in England when they were manufacturing batteries for experimental or exhibition purposes. The FitzGerald-Jones plan was to mould a solid peroxide plate, and attach a framework of celluloid to the edges and parts of the surface thereof. On the inside of this frame, between the frame and the peroxide plate, was a thin strip of platinum; but this construction was contemplated and perfected by Sellon long prior to the time of its adoption by FitzGerald-Jones. This third patent, No. 396,769, was issued on the same date as the others above referred to. One claim reads: 'In a battery, a support or terminal containing a practically inoxidisable material, combined with a conductor of platinum and a mechanically applied active material substantially as described.'

"These three patents are all believed to be valid. If so, their ownership places the Electrical Accumulator Company in position to control the accumulator or secondary battery industry of the Faure patent."—*Electrical World.*

Similarity of Address.—Messrs. Arthur B. Gill and Co. write, asking us to call attention to the fact that mistakes have arisen owing to their works being at No. 4, while a sale is to take place at No. 5, Bombay-street. There are a good many people, unfortunately, who jump at conclusions, and two works of a like nature next door to each other always leads to confusion. However, we are glad to be informed that Messrs. Gill and Co. are very busy; they are not interested in the Sun Electric Light Co., whose affairs have given rise to these troubles, and care should be taken to note the difference of title and address.

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NOTICE.

During the course of the past year we issued steel engraved portraits of Mr. E. Graves, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. Wollaston, M.D., F.R.S., *and* Sir Humphry Davy, F.R.S. *The portraits of* Prof. D. E. Hughes, F.R.S., *and of* Dr. J. Hopkinson, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

THE STOCK EXCHANGE.

Did any reader ever see the sensitive plant? If so, they will know how it answers every touch. The Stock Exchange is a sensitive plant of another kind, answering every touch, and by its actions writing history sometimes in a most uncomfortable manner. Like the sensitive plant, the Stock Exchange is unable to distinguish between friend and foe, and so it treats all alike. It may be almost taken for granted that its actions are automatic, and guiltless of the merest soupçon of reason. At one moment there is a panic, the cause of which is hidden from ordinary eyes, at another time the most unreasoning confidence is shown in concerns that to the ordinary intellect appear to be as rotten as the apples of Sodom. Of course, the whole meaning of this state of things lies in the fact that the Stock Exchange is purely and simply a gambling hell, and that its sole end and aim is to pick up the crumbs which fall at every turn of the market. A large number of shareholders in most bona fide concerns are investors as distinguished from speculators. The action of the Stock Exchange generally tells somewhat heavily against investors, for, with the proverbial cussedness of things mundane, the investor usually wants to realise when the market is against him. However, we have no wish to analyse the inner workings of Stock Exchange matters, and certainly we have no desire to seek for the consciences of its habitués. The Stock Exchange has occasional fits of compunction, for we all know that

"When the devil was ill, the devil a monk would be;
When the devil was well, the devil a monk was he."

And for a time something is to be done. The fit passes away and promotion and speculation are as rampant as ever, and so the world goes on. It will be seen that we believe the Stock Exchange and all connected therewith altogether out of the commercial sphere of salvation.

It may be well just at the present moment to look from the investor's point of view at the position of the electrical companies engaged in litigation. Suppose, in the first place, that success still attends the Edison-Swan combination in the Lords' appeal. The Brush Company will then be solely dependent upon its business outside lamp-making to produce a dividend to its shareholders. The profits hitherto obtained and paid—leaving out of consideration the speculative era—have been made from business other than lamp-making, and there is every indication that this, what may be termed the legitimate business of the company, will increase and multiply. The profits earned should increase with the increase of business, and if heretofore it has been possible to earn a dividend, it should year by year be easier to earn a similar or a larger dividend. The shares have recently touched par, and are now but little below it. Why they should have

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dropped may be from fear of law costs, but at the very worst these will not affect the permanent position of the company. The position of the Edison-Swan combination is far different. The shares in this company have long been considerably below par. According to the reports issued to the shareholders the position of the company has gradually become better, but so far dividends have been unknown, the profits having been put to a reserve fund in regard to the contingencies which might arise out of the litigation. The obtaining of a virtual monopoly would ensure a dividend if there is no further litigation in other quarters. Hence in our opinion, while the Brush Company is fully able to earn dividends from sources independent of lamp-making, the Edison-Swan combination necessarily looks to its manufacture of lamps as the principal source of income. This is as it should be, the speciality of the former company being its dynamos and heavy electrical apparatus, that of the latter its lamps. In the one case lamps are subsidiary, in the other heavy apparatus is subsidiary. No doubt the Brush, and, indeed, many other companies, would like to get the profit upon the lamps they could in the ordinary course of business sell, but in the case we have assumed that is not to be. There is the opposite result to be considered when the Edison-Swan combination find their monopoly destroyed. If this should be the case, it would have to take its chance in the competition against a number oi manufacturers who would commence to manufacture. In such competition they have immense advantages. In the first place, if they play their cards correctly, they should have a hold of a great majority of the purchasing public. If every attempt is made to meet the demands of purchasers to produce the best class of goods at a fairly cheap rate, any competitor would find it difficult to get much of a footing in the market. But, of course, the company would not be in the good position it would if the monopoly is determined. In the one case, we say good dividends ought, with good management, to be a certainty; in the other, they would be reduced to a probability.

It would be interesting to know something as to the number of shares changing hands in various kinds of companies. Is the number greater when the concern is flourishing and paying, and what is the average length of time shares in such companies are held? We presume that these shares fall more into the hands of investors, and do not change hands so frequently as in the case of companies where the sole profits are due to the rise and fall of the market. In the latter case, some shares are usually held during long periods; for a man not compelled to sell at any particular moment waits and watches for the good time coming. Meanwhile, the Stock Exchange takes advantage of every rumour, and makes its bargains accordingly. Its actions should be viewed with caution, and investors should not be in a great hurry to follow its lead, and, in fact, not to follow at all till after due consideration and investigation. The two companies specifically referred to have made some provision for awkward contingencies, and we think the sketch we have given of their position in any case is fairly accurate.

ELECTRICAL ENGINEERS AND ACCIDENT INSURANCE.

It is well known that the name "electrical engineer" has hitherto conferred upon its owner the proud privilege of paying £6. 5s. per year premium on an insurance of £1,000 in the Accident Insurance Company, instead of a premium of £4, which is the ordinary rate. One or two of the minor companies have not strictly adhered to this rule, and we now have to chronicle the giving way of the principal English company. A short since one of the local agents of the company, Mr. Maynard, station-master at Bromley, Kent, had occasion to send in a form of proposal from Mr. Schiassi, an electrical engineer. The result was an intimation that the premium would be as above stated, but, after a good deal of correspondence between these parties and the head office, Mr. Vian has given way, and in future all electrical engineers not directly engaged in the working of the machinery—such, for example, as linemen, foremen, superintendents, etc. —can be insured at the ordinary rate. Many of our readers will remember a discussion on this very subject some years ago, initiated by Mr. Dowsing, of Messrs. Crompton and Co. At that time it was pointed out that while some electrical engineers might well come under the "hazardous risks," there were a large number who no more hazarded their lives or their limbs than the parson or the schoolmaster. The addition of more than 50 per cent. to the premium is a consideration not likely to be overlooked by men who are not overpaid, and the gentlemen who have fought the fight to success must be congratulated upon the result.

ELECTRICAL MEASUREMENT.*

BY PROFS. W. E. AYRTON, F.R.S., AND J. PERRY, F.R.S.

(*Verbatim report of the abstract of the Paper given by Prof. Ayrton at the meeting.*)

The rapid development of electricity for commercial and industrial purposes makes it quite unnecessary for me to give any preface as to the importance of methods for the exact determination of the values of current and potential differences, and of the making of portable and simple apparatus to enable practical men to measure quickly and accurately the quantities that are so necessary to be measured for determining the value of any particular distribution of electricity.

* Paper read at the Physical Society, February 23, 1889. Prof. Reinold, F.R.S., in the chair.

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It is well known that when a galvanometer is used for measuring current simply, the alteration of its resistance, whether by change of temperature in the room, or by heating due to the passage of the current, is of no consequence; whereas when the galvanometer is used as a voltmeter for measuring potential differences, the change of resistance, whether due to change of temperature of the room, or to heating of the instrument by the passage of the current, is all important because the resistance due to the rise of temperature diminishes the sensibility of the instrument. For that reason Prof. Perry and I attempted to solve this question some years ago, with reference specially to our own magnifying spring voltmeter, and to determine what was the proper metal to wind it with, and what was the proper law according to which the thickness of the wire should vary as the centre was departed from, in order that the heating error should be a minimum—that is, the error due to the maintenance of the P.D. at the terminals of the voltmeter; and the results were communicated to this society in 1885. For the purpose of making the calculations in that paper, we were compelled to assume a fairly simple law for the variation of the effect of a coil as you departed from the centre, and also of a fairly simple law for the connection between the thickness of the covered wire and the thickness of the copper or uncovered conductor. The calculation was difficult enough indeed, even when simple laws for these variables were assumed. The results obtained were that, in order to make the voltmeter such that there should be the least probable variation of resistance when a given potential was maintained, the instrument should be wound with copper, and not, as was usually supposed to be right, to wind it with german silver, and further, that the diameter, in our particular instrument, of the uncovered wire should vary according to the distance from the centre raised to a certain power—viz., ·42. This result, as a matter of fact, has been followed by the makers of our instruments, but as, of course, it would be too difficult for them to make the diameter of the copper wire vary in each layer, they have used only three, or in some cases four, gauges for winding a voltmeter.

Since 1885, the metal platinoid has been brought before our notice; this has a temperature coefficient less than half that of german silver. Experiments have also been made at the Central Institution by the first year's students on the temperature coefficient of phosphor-bronze, and they find that the variation of resistance by temperature of phosphor-bronze, a metal of very much lower specific resistance than german silver or platinoid, is only ·082 per degree C. Phosphor-bronze wire increases its resistance by about ·082 per cent. per degree C., and has a resistance per cubic centimetre at 0deg. C. of about 9·7 microhms. Therefore, the question has now to be considered by taking platinoid and phosphor-bronze into account.

The whole subject may be treated in a far simpler way than we treated it in our paper of 1885, if the same gauge of wire is used throughout the instrument. That is not quite right, because, as a matter of fact, we use three gauges in the actual voltmeters. At that time we assumed the thickness of the insulating covering to increase proportionately with the diameter of the metal. That is not right. Now we are able to treat the subject by really taking into account the proper way, in which the insulating cover varies with the copper used in winding. The result is surprisingly simple, and it will therefore be interesting to the members.

The first well-known equation is that if you take a certain deflection of a definite instrument, made of a particular shape and form, and having a certain controlling force, due to a spring or otherwise, is

$$A = \frac{F}{n},$$

where A is the current in amperes, n the number of windings, and F a constant depending on the type of the instrument, but not on A, or on n. Next,

$$n = \frac{P}{D^2},$$

where P is half the area in square centimetres of the cross-section of the coil through its axis, and

$$r = \frac{4\,l\,\rho}{\pi\,d^2},$$

where r is the resistance of the instrument at the temperature it happens to be at, ρ the resistance per cubic centimetre of the metal employed at the same temperature, l the length in centimetres of the wire used in winding the instrument, and d the diameter in centimetres of the *uncovered* wire. Also

$$l = \frac{U}{D^2}$$

where U is the constant volume in cubic centimetres filled with wire, and D the diameter in centimetres of the *covered* wire.

$$\therefore A = \frac{F\,D^2}{P},$$

$$r = \frac{4\,U\,\rho}{\pi\,D^2\,d^2},$$

and the watts required to be expended to produce this deflection

$$A^2\,r = \frac{4}{\pi}\cdot\frac{F^2}{P^2}\,U\,\frac{D^2}{d^2}\rho$$

$$= K\,\frac{D^2}{d^2}\rho \text{ say}$$

when K is a constant depending solely on the type of instrument, but not at all on the gauge or material of the wire. Hence the watts required to produce a particular deflection will be proportional to the ratio of the square of the diameter of the covered wire to the square of the diameter of the uncovered wire multiplied by the specific resistance of the material used in winding the instrument. If $D \div d$ were a constant—*i.e.*, if the diameter of the covered wire increased in proportion to the diameter of the uncovered wire—it would mean, as is well known, that the number of watts required to produce the maximum deflection would be independent of the particular wire used in winding the instrument; the instruments would be equally hot if a particular deflection were obtained, no matter what gauge of wire was employed. But $D \div d$ is not a constant, and is larger for wire of small gauge than it is for wire of a large gauge, and, therefore, an instrument intended to measure many volts will get hotter, when a given deflection is produced, than a similar instrument wound with thinner wire intended to measure fewer volts.

Next we have the equation $V = A\,r$, where V is the P.D. in volts maintained at the terminals of the instrument, when the given deflection is produced.

$$\therefore V = \frac{4}{\pi}\cdot\frac{F\,U}{P}\,\frac{\rho}{d^2}$$

Or the number of volts necessary to produce a particular deflection is proportional to $\rho \div d$, which means simply the resistance of the wire per unit length, the resistance of a centimetre of the wire uncovered. You come, then, to this very simple result. Take any one instrument of a particular type, then the volts required to produce a given deflection simply depends on the resistance of a centimetre of wire whatever the material it is made of, and whatever thickness of silk is used in covering it, and therefore the wire necessary to be used to give the voltmeter a particular range can be easily predetermined. The wire can be wound to any thickness in one instrument, and to any thickness in another, and you can at once say that the volts required to produce a certain deflection in the one is to the volts required to produce the same deflection in the other, simply as the resistance of the uncovered wire per unit length. This idea, which first was suggested to us in a conversation with Mr. Crawley, we have, by the preceding reasoning proved to be generally true, and it enables us to make calculations in a very easy way. It is somewhat surprising, on considering it fully, that when there are three variables—the diameter of the wire, the material of the wire, and the thickness of the insulating cover—employed, that it is so easy to specify what will be the number of volts required to produce a specific deflection—viz., the number proportional to the resistance per centimetre of the wire.

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Next we want to consider the change of the resistance by heating, which determines the percentage error of a voltmeter—*i.e.*, the percentage variation of the deflection that will be produced by keeping on the volts for a considerable time. The change of the deflection from the moment of first putting on the volts, the diminution in the deflection that occurs after an application of the volts for a considerable time, can be thus determined.

Let ρ_0 be the resistance per cubic centimetre at 0° deg. C. of the material used in winding a voltmeter, T the temperature in degrees centigrade at which the graduations are correct (which we will assume to be the present temperature of the room), and t, the temperature acquired by the instrument when the P.D. necessary to maintain a given deflection is maintained for some time between its terminals, then the rate of production of heat in watts equals

$$K \frac{D^2}{d^2} \rho_0 (1 + a t)$$

where a is the coefficient of increase of resistance per 1 deg. C. of the material used in winding the wire. Let S be the cooling surface of the instrument in square centimetres. ϵ is the rate of loss of heat in watts per square centimetre, per second, which we find equals about 0·001—that is to say, if you have any conductor radiating freely into the air, the temperature, no matter what the conductor is made of, will be raised about one degree above the temperature of the air when one watt per thousand square centimetres of surface is applied to it—that is the value of ϵ.

Hence—

$$K \frac{D^2}{d^2} \rho_0 (1 + a t) = S \epsilon (t - T)$$

$$\therefore t = \frac{S \epsilon T + K \frac{D^2}{d^2} \rho_0}{S \epsilon - K \frac{D^2}{d^2} \rho_0 a}$$

If r_T and r_t be respectively the resistances of the instruments at the temperature of graduation, and when the given deflection has been maintained for some time, the percentage heating error is

$$100 \frac{r_t - r_T}{r_T},$$

which equals

$$100 \frac{\rho_0 (1 + a t) - \rho_0 (1 + a T)}{\rho_0 (1 + a T)}, \text{ or } 100 \frac{a (t - T)}{1 + a T},$$

and this, when the value of t given above is substituted, finally reduces to

$$\frac{100}{\frac{S\epsilon}{a \rho_0 K} \frac{d^2}{D^2} - 1}.$$

Now, how does the diameter of covered wire vary with the diameter of the covered wire? We find from the examination of a large number of samples of wire that the diameter of the covering does not increase by any means in proportion to the diameter of the uncovered wire, but wire varying from ·003in. upwards to ·05in. has an increased diameter of about ·003in. We will take the case of four voltmeters, made identically the same mechanically, one wound with copper, one with german silver, one with platinoid, and one with phosphor-bronze; those seem to be the substances that are most worthy of consideration. We will suppose that the four instruments are so constructed that the same number of volts applied to each instrument produce exactly the same deflection, so that they would be equally good, so far as sensibility is concerned, for the user: if they were all put in parallel they would all give exactly the same deflection to start with. From the simple rule that I gave you it is easy to calculate what must be the diameters of the four metals employed to wind those instruments. We will take one to start with. It will depend upon the given range; suppose the range is such that a 5-mill. copper wire will give the maximum deflection for the number of volts required, it is easy to calculate what must be the diameters of the other wires, because, as I told you, we have a very simple rule connecting the volts required to produce a given deflection with the diameter of the uncovered wire. In fact, we merely have, to settle this question, to simply calculate what must be the diameter of the four wires — copper, german silver, platinoid, and phosphor-bronze—so that they may have the same resistance per centimetre without any regard to whether or not there is the same insulating cover. If you have ·005in. for copper, in order to have the same resistance per centimetre of length, you will have ·018in. for german silver, ·023in. for platinoid, and ·012in. for phosphor-bronze; those are the wires that we must select. If they are all uncovered under ·050in., a manufacturer will cover them all with the same thickness, and the ratio for d to D for copper will be about 5 to 8, for german silver 18 to 21, for platinoid 23 to 26, and for phosphor-bronze 12 to 15; that is, the ratio of d to D, using d so as to have the instruments of the same range, producing the same deflection with the same number of volts. If these values are used, and you take into account the value of a, the temperature coefficient of the different materials, and of ρ_0, you can ascertain the heating error in each instrument. Curiously enough, if you take 5-mill. wire as being the wire right to use in the case of the copper wire voltmeter, to get the right range for the particular instrument, then we find, on substituting the values of $d \div D$ of a and of ρ_0 in the formula given for the heating error, that the metals arrange themselves in the following order as to their relative advantages in using them. It is best to use platinoid, which gives you the minimum temperature error; phosphor-bronze is the next, although phosphor-bronze is a metal not differing in specific resistance so very much from copper—it is a good deal higher, but it is more of the copper order—german silver comes next; lastly, copper. If the instrument be of such a range that ·005 copper is the proper wire to use, then the metals arranged in descending order are platinoid, phosphor-bronze, german silver, and copper; but german silver and copper are nearly equal, so that, curiously enough, our original conclusion of 1885, at any rate for this gauge, was not far wrong in spite of the fact that we assumed that the thickness of the insulation was proportional to the metal, which was wrong. Suppose, next, we are dealing with voltmeters of a lower range. I want, say, four voltmeters to measure, not 100 volts, but all to measure up to only, say, 50 volts. Ten mills. is the proper diameter, we will suppose, for a copper wire for that instrument, then, curiously, the metals arrange themselves in this order of descending value as regards the heating error. Platinoid again comes first—it is the best metal to use—phosphor-bronze again second, but now copper is better than german silver, which is the worst. It appears, therefore, that the idea existing among manufacturers that you ought to make a voltmeter of german silver in order to obtain the minimum temperature error when keeping on the P.D. is quite wrong, as we have always held. It appears to be wrong even when you take into account the real thickness of the insulated covering, and not simply employ an assumed law for the insulating covering.

The conclusion one comes to, therefore, is that you should certainly use platinoid wire, next to that phosphor-bronze, and if you are using a copper wire as thick as 10 mills. it is better to use copper than the equivalent german silver wire; they are very nearly on a par, but it is curious to see that german silver is the worst to employ of the four. This result, bear in mind, is not dependent on the shape or form of the voltmeter.

You will understand that in this consideration I am dealing with the error due to the heating in consequence of keeping on the volts. I am not considering the change of temperature of the room—that is easy enough to allow for—but we are considering the slight falling of the reading which occurs with most voltmeters, due to a prolonged maintenance of the P.D. between the terminals. If the instrument gets hot through the passage of the current, the resistance increases, and its deflection therefore falls. It would be worse to use german silver, if you started with a 10-mill. covered copper wire, than if a copper wire were used; and it would be much better to use platinoid or phosphor-bronze. That is the first conclusion arrived at in this paper.

(To be continued.)

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THE ZIPERNOWSKI-DERI ALTERNATE CURRENT SYSTEM.

BY F. B. BADT.

I read with interest the statement in the *Western Electrician* of January 12th that the Zipernowski-Deri transformer system was to be commercially introduced into the United States. It struck me at the time that I had never seen a full and complete description of this interesting system in any of the American electrical journals, and as I have lately returned from Europe, where I had an excellent opportunity of thoroughly looking into the merits of this apparatus, I have undertaken the preparation of this article. The alternate dynamos for lighting by means of transformers made in the United States are all representatives of one type. They all have drum armatures revolving inside of the field, consisting of an iron drum carrying a number of magnets with their poles directed toward the armature. The main type of European alternate dynamos for transformer distribution is that of Ganz and Co. of Buda-Pest, Hungary, which is manufactured under the Zipernowski-Deri-Blathy patents. This system is in operation in a considerable number of central stations on a paying basis. The Zipernowski alternate dynamo belongs to that type which has a stationary drum armature, the field, with its radial magnets, revolving inside. The smaller dynamos are self-exciting, while the larger machines have separate exciters. That the E.M.F. may be kept constant in the primary coils of the transformers —which, of course, are connected in multiple arc—the dynamos are compounded.

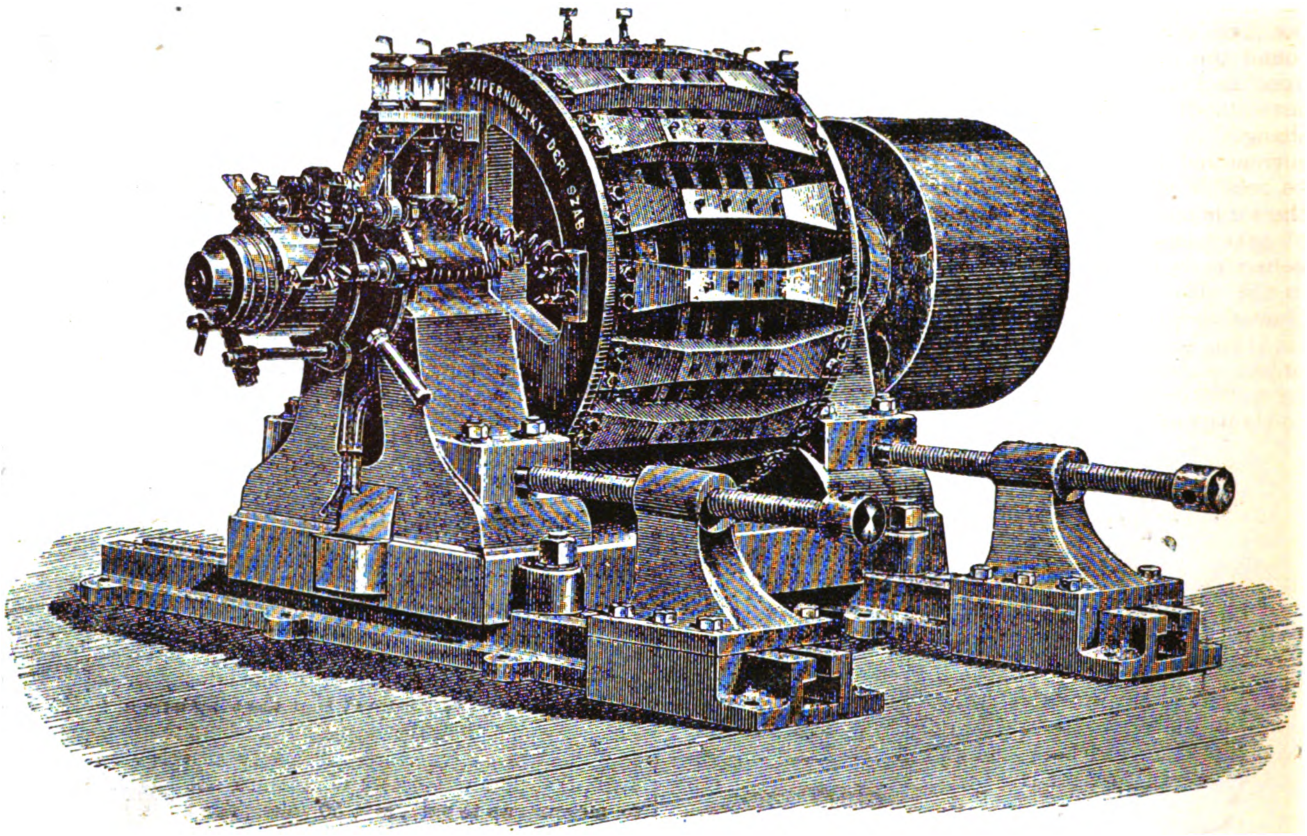

FIG. 1.—Zipernowski-Deri Alternating Current System Self-Exciting Compound Dynamo.

Fig. 1 illustrates a self-existing compound alternate current dynamo. It has eighteen poles, and yields 60,000 watts. The field revolves 500 times per minute. The E.M.F. is 1,800 volts and the commercial efficiency of the dynamo is 90 per cent.

The armature is composed of a stationary laminated iron drum of cylindrical form, on the inner side of which are disposed the armature-coils of curved form (Fig. 2) wound on iron cores, not shown in the cut. The radial field-magnets, with their respective coils, constitute the moving part. The commutator has as many segments as there are magnet poles in the machine, the alternating segments being in electrical contact with each other, as shown in Fig. 3. At each reversal the commutator so directs the alternating currents that the several impulses follow in the same path in the coils of the magnets, and thus the machine becomes self-exciting. The current necessary to excite may be taken as a shunt to the terminals of the generator or from a special armature-coil reserved for this purpose. The exciting current may also be furnished by a transformer called a magnetiser, connected to the main line or the terminals of the generator. In all these cases the exciting current, supposing the dynamo to be already compounded, would be of nearly constant E.M.F. and

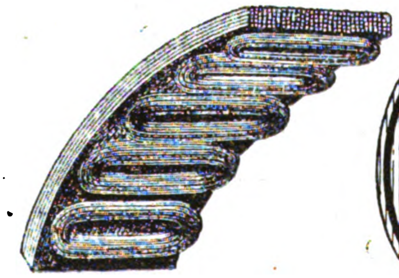

FIG. 2.—Section of Armature.

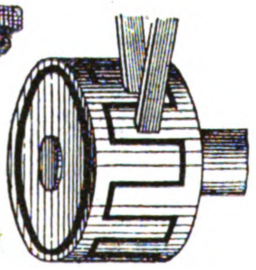

FIG. 3.—Commutator for Self-Exciting Alternating Dynamo.

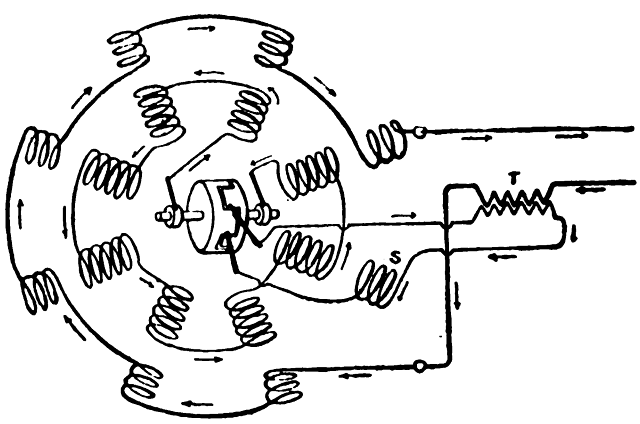

FIG. 4.—Plan of Compound Alternating Dynamo

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strength. But for maintaining a constant E.M.F. at the terminals of the generator it is necessary to increase the magnetisation in proportion to the increase of the external current supplied by the generator, and as it is even desirable to have a somewhat higher E.M.F when the generator is running with full load as when an open circuit, the magnetisation will have to be increased very considerably. In this case the magnetising current traverses one of the coils of a special transformer, or compensator, while the second coil of this compensator is introduced in the main circuit of the generator in such a manner, that the two currents are circulating in opposite directions round the iron core. The two currents will mutually act upon each other, and the effect will be that the exciting current will increase and decrease, corresponding to the changes in the main current. If the original exciting current and the compensator are properly adjusted, it will be possible to maintain the E.M.F. constant, not only at the terminals of the dynamo, but at the end of a conductor of given length. The E.M.F. at the terminals of the generator will rise somewhat with the increasing intensity of the main current. By such an arrangement the influence of part of the resistance of the high tension main line can be done away with in cases where the nearest object to be supplied is situated at a considerable distance from the central station. Fig. 4 is a diagram of an eight coil compound alternate dynamo. The inside coils are

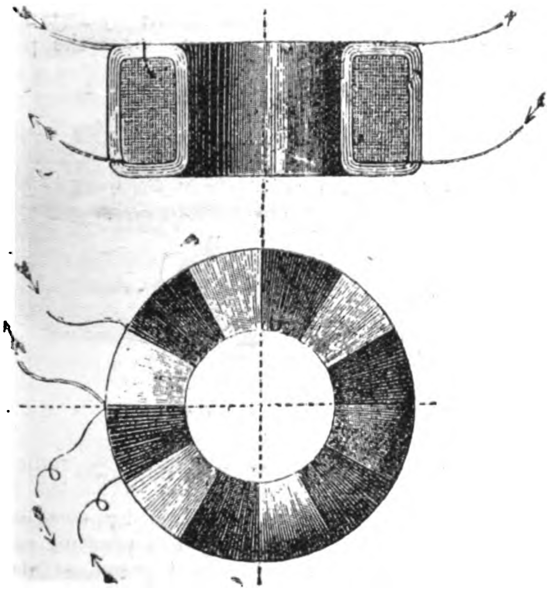

Fig. 5.—Transformer, Form No. 1.

those of the field, and the outside coils those of the stationary armature. The current of the armature-coil, S, is reserved for the magnetisation of the field, and for this purpose is connected with the commutator. T is the compensator. It is clear that instead of using the current of coil S, a transformer might yield the magnetising current for the field.

Ganz and Co. build their alternate dynamos in the following sizes:

Type.	1	2	3	5	6	7	8
Watts:	10,000	20,000	30,000	50,000	80,000	160,000	320,000
Revol. per min.:...	830	830	625	500	360	170	125
No. of magnets....	6	6	8	10	14	30	40
E.M.F...............	900	900	1,800	1,800	3,600	3,600	3,600
Per cent. commercial efficiency....	85	85	90	90	92	92	93

The Zipernowski transformers have been described too often and are too well known to require any minute description. Two forms are generally used. In the first form (Fig. 5) a ring or hoop-shaped iron core, made of thin iron wires, ribbons or plates, is wound with two coils of copper wire much in the manner of a Gramme ring. The windings, however, are connected in such a way, that the primary current circulates in all spires in the same direction round the core, and no free magnetic poles are formed. In the second form (Fig. 6) the iron and copper parts are reversed, the two coils of copper wire forming a ring or hoop which is completely enclosed by thin iron wires, ribbons or sheet iron, the subdivided iron conveying the lines of magnetic force. The more delicate copper windings are entirely enclosed by the iron, and thus shielded against accidental damaging.

A transformer of the latest design, having 10 h.p. nominal capacity, gives the following electric data:

Weight of iron core		90 kilogrammes
,, copper in primary coil		16 ,,
,, ,, secondary coil		22 ,,
Resistance of primary coil		4·6 ohms.
,, secondary coil		0·013 ,,
Difference of potential at primary terminals		1,873 volts.
Difference of potential at secondary terminals		102 ,,
Ratio..		18 to 1
Strength of primary current......	with full load on	4·28 amperes.
,, secondary ,, ...	with full load on	75 ,,
Primary energy consumed	with full load on	8,017 watts
Secondary energy supplied	with full load on	7,650 ,,
Commercial efficiency...............	with full load on	95·4 per cent.
Reversals of current..		100 per second.

On open secondary current this transformer will take 17 amperes of primary current, which is equal to 210 watts of energy expended, though the apparent product of volts and amperes will give about 50 per cent more.

Prof. Galileo Ferraris, who made a series of experiments and measurements at the Italian Museum of Industry in Turin, concludes his report, in which he compares transformers of the Gaulard and Gibbs and Zipernowski and Deri types as follows:

"The comparisons which we have just made are sufficient to demonstrate that the annular form of transformer is

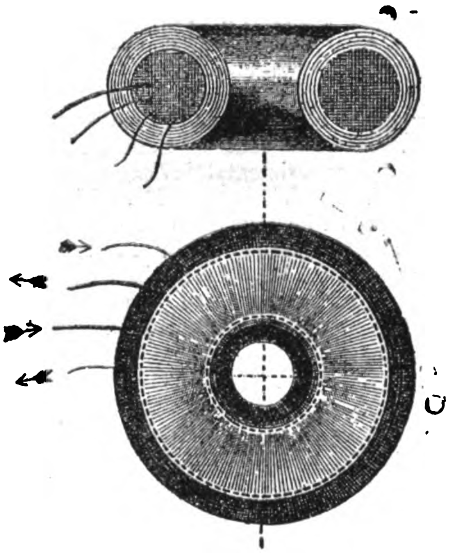

Fig. 6.—Transformer, Form No. 2.

much better than that of the disc secondary generators. This is easily explained, for we can demonstrate *a priori* that the form of the annular transformer is not merely very rational, but that it is, perhaps, the best of all that could be devised for the purpose of obtaining great coefficients of induction with low resistances and small weights of copper.

"1. To have a large surface of spirals with the smallest possible mass of metal, we must remove as much as possible of the metal from the centre of the spirals, and consequently we prefer wire to discs.

"2. To obtain the largest surface of spirals possible with the least length of wire, we must have a small number of spirals with a great diameter.

"3. To give the iron core the maximum efficiency, it is advantageous to give it a closed form. Now the layer of iron which covers the annular transformer is evidently equivalent to a core closed upon itself.

"4. To avoid Foucault currents, the continuity of the iron must be interrupted precisely as it is done by employing, instead of a single mass, a varnished iron wire, rolled up in such a manner as to be everywhere perpendicular to the currents.

"We are thus led, quite naturally, to the arrangement adopted by Zipernowski, Deri, and Blathy.

"Lastly, it must be noted that the induction produced by the currents which circulate in the coils of the annular transformer is sensibly independent of the place which

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these coils occupy in the interior of the stratum of iron, where they are entirely enclosed, and that consequently, both in the annular transformer and in that with the discs, the primary and secondary coils are under identical conditions as regards the iron."

Ganz and Co. manufacture, in connection with their alternate dynamos and transformers and necessary appliances, also alternate current meters and alternate motors, of which a description will be given at some future time. They do not make incandescent lamps, but use in their stations lamps of various manufacturers, such as Siemens, Edison-Swan, Cruto, and others.—*Western Electrician.*

ON THE DESIGNING OF CONTINUOUS CURRENT DYNAMO MACHINES.*

BY PROF. JAMIESON, M.INST.C.E., F.R.S.E.

No machine has received such constant and unremitting attention of late as the dynamo, both from men of science and from practical engineers. From being a comparatively badly designed and inefficient machine, in 1880 giving then only some 50 to 60 per cent. commercial efficiency, it now produces over 70 per cent. of the dynamic power applied to it in the form of useful electrical power, and the electrical efficiency or ratio of electrical output to total electrical power generated often exceeds 90 per cent. Until within a very few years ago, dynamos were designed and proportioned by a rule of thumb system, or trial and failure until moderate success was attained. If a maker had luckily hit upon successful results from one machine, he copied by proportion the dimensions and materials arrived at for his other larger or smaller machines, without exactly knowing the precise causes which gave success in the one case, or failure in the other. Now all that is changed, thanks to the mathematical and experimental investigations of Dr. John Hopkinson, Prof. S. P. Thompson, Mr. Gisbert Kapp, and many of the more eminent makers of dynamos, as well as to the very exact experiments by Prof. Ewing on the magnetic permeabilities of different classes of iron.

If a dynamo is now required to give any desired power, the whole of its proportions and sizes can be calculated and drawn down with such accuracy that, when constructed, it will fulfil the stipulated conditions to within 2 or 3 per cent., with a minimum of experiment and alteration in the workshop.

Let me here add the power is not measured by any system of "nominal power," but by actual, useful output. Engineers have of late been discussing in this institution whether or not they should adopt one or other of the various rules for estimating the "nominal horse power" of steam-engines. Nothing gives greater annoyance to an electrical engineer than having to reply to the question, "What is the nominal horse-power required to drive such and such a dynamo?" He at once discards this term, and deals directly with the brake, or indirectly with the i.h.p. of the engine.

In the short time at the disposal of the author, he proposes to confine his remarks and calculations to "Continuous Current Constant Pressure Compound Dynamos," as now used for supplying current to ordinary incandescent lamps arranged upon the parallel system, or those dynamos which work in accordance with the methods illustrated by Figs. 1 and 2.

C_a, C_m, C_s, C_e, represent the currents in the armature, main magnet-coils, shunt-coils, and external circuits respectively, the direction of these currents being indicated by arrows.

R_a, R_m, R_s, R_e, represent the resistances of these same parts.

E_a and E_e represent the E.M.F. or pressure generated in the armature, and the external E.M.F., or difference of pressure between the positive and negative terminals (T + and T –) respectively.

A M and V M represent current and pressure meters, or ampere and volt meters.

It is not our intention to enter here into the many mechanical and electrical arrangements of dynamos, or to trace the manner in which dynamos have been gradually simplified and cheapened. Yet as many of the members of this institution are not familiar with the internal construction of such machines, we think that the simple illustrations may assist them, and lead them to take a greater interest in the principles and formulæ which follow.

The first skeleton figure gives an idea of the general arrangement of the series Gramme dynamo, one of the few, and certainly the best machine in the market in 1880.

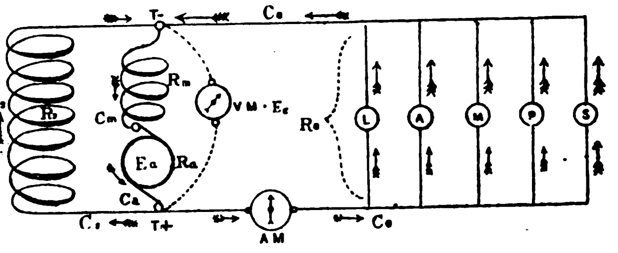

FIG. 1.—Theoretical diagram of Faraday dynamo connections. Ca, Cm, Cs, Ce represent the currents in armature, main magnet coils, shunt coils, and external circuits respectively, the direction of these currents being indicated by arrows; Ra, Rm, Rs, Re represent the resistances of these parts; Ea, Ee represents the E.M.F. in armature and on external circuit.

Fig. 1 illustrates the Faraday dynamo, as made in 1887-88. This form of dynamo gives excellent results, but the makers finding that it is more expensive to construct than the Kennedy dynamo shown by Fig. 2, they are now getting out a set of patterns to meet the present popular craving for cheap machines, with cast-iron core and pole-pieces having but one joint, instead of a wrought-iron core and two joints.

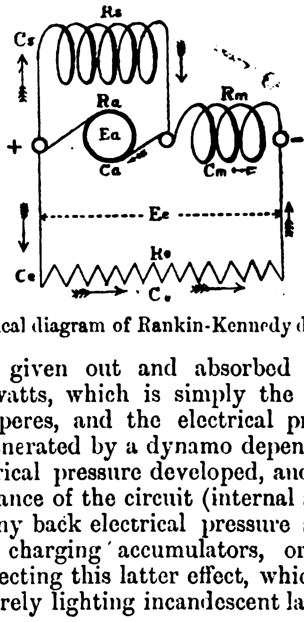

FIG. 2.—Theoretical diagram of Rankin-Kennedy dynamo connections.

The power given out and absorbed by dynamos is measured in watts, which is simply the product of the current in amperes, and the electrical pressure in volts. The current generated by a dynamo depends directly upon the total electrical pressure developed, and inversely upon the total resistance of the circuit (internal and external), as well as upon any back electrical pressure such as is experienced when charging accumulators, or when driving motors. Neglecting this latter effect, which does not take place when merely lighting incandescent lamps,

Let E_a represent the electrical pressure generated in the armature.

E_e „ external electrical pressure, or that available for useful work.

R_i „ internal resistance of the whole dynamo.

R_e „ external resistance of leads and lamp circuits.

C_a „ current passing through armature.

C_e „ current external, or that sent through lamp circuit.

Then, $C_a = \frac{E_a}{R_i + R_e}$ = total current generated

And, $C_e = \frac{E_e}{R_e}$ external current.

The electrical efficiency $= \frac{C_e \times E_e}{C_a \times E_a} = \frac{\text{output in watts}}{\text{total watts generated}}$.

Now, since C_a, E_e, and C_e depend directly upon E_a, we propose to show how this internal electrical pressure may be obtained for any dynamo of the kind under consideration.

* Paper read before the Institution of Engineers and Shipbuilders of Scotland.

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This total or internal pressure, E_a, depends directly upon:

1. The total number of magnetic lines which flow between the field-magnet poles through the armature.
2. The number of convolutions of the armature conductors which are in series at one time.
3. The speed of rotation of the armature.

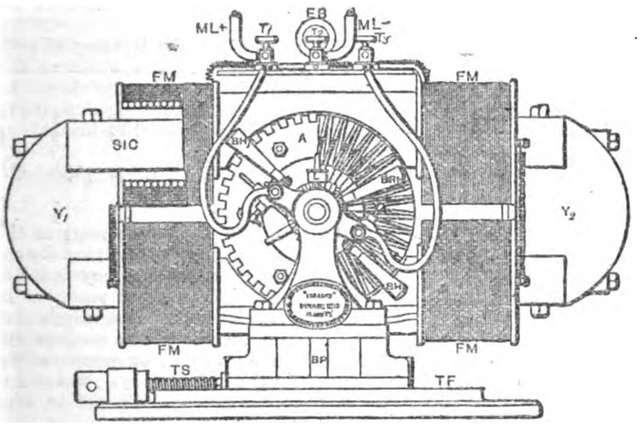

FIG. 3.—Faraday dynamo. BP, bed plates; TF, tightening frame; TS, tightening screw; FM, field magnets; Y_1Y_2, field magnet yokes (cast-iron); SIC, soft iron cores; A, armature; BH_1BH_2, brush handles; ML+ ML−, main leads (positive and negative); $T_1T_2T_3$, terminals.

The *number of revolutions* per minute is a matter that can be easily decided upon before beginning to design the dynamo. Fast-speed dynamos, if well balanced, are common in land installations; slow-speed ones on board ship, and when vibration and noise must be avoided.

The *number of convolutions* of the armature conductor depends upon the number of radial bars in the commutator, the diameter of the armature, and the size of wire to be used, all of which will be determined as the drawing or design proceeds in accordance with sound practice.

The *magnetic circuit* is the chief and most intricate part of the whole design which requires our attention, and we shall therefore consider it first in full detail.

I. Field-Magnet Circuit.

The field-magnet circuit should have as little magnetic resistance as possible. The magnet cores, etc., *should* therefore be made of the best soft Swedish iron, short, of large sectional area, and with no joints. Owing, however, to expense, the difficulty of winding the wire on the magnets, or the fixing of bobbins containing the wire, and the necessity of having sufficient residual magnetism with which to start the dynamo current, and to prevent fluctuations of current, the yoke (if there is one) and the pole-pieces are frequently made of cast iron.

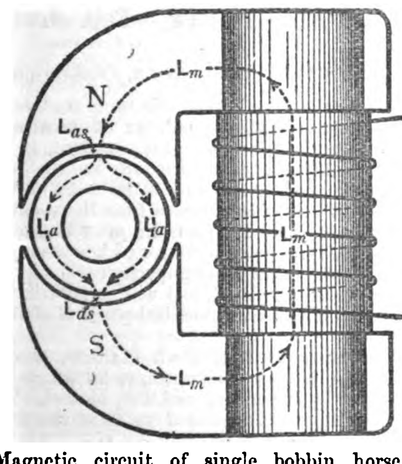

FIG. 4.—Magnetic circuit of single bobbin horse shoe Kennedy dynamo. Lm represents length of field magnet circuit; Las represents length of air space circuit; La represents length of armature circuit.

In a Kennedy dynamo (Fig. 4), the mean length of the magnetic circuit is indicated by the letter, $\mathbf{L}_m$, and the poles are marked N and S.

II. Air Spaces.

The air spaces should have the least possible magnetic resistance. They should, therefore, have as little depth as is consistent with preventing actual contact between the armature wires and the pole-pieces, and of allowing free circulation of air, and of preventing heating of the pole-pieces due to Foucault or eddy currents in the forward ends of the pole-pieces.

In Fig. 4 the two air-spaces are marked, $\mathbf{L}_{as}$, $\mathbf{L}_{as}$.

III. Armature Core.

The armature core should have as little magnetic resistance as possible, and be as free as possible from inducing Foucault currents. It should, therefore, be built up of the softest thin Swedish iron plates, well insulated from each other, and laminated or placed in a direction parallel to the direction of the magnetic lines passing between the poles of the field-magnet. Some makers prefer to build up their armature cores of soft-iron wire insulated by the natural thin coating of oxide of iron always found on such wire.

In Fig. 4, the mean directions of the split magnetic circuit through the armature core are marked $\mathbf{L}_a$, and $\mathbf{L}_a$.

IV. Magnetic Resistance of Field-Magnet Circuit.

The magnet circuit, $\mathbf{L}_m$, has a magnetic resistance.

$$\mathbf{R}_m = 2\frac{\mathbf{L}_m}{\mathbf{S}_m}.$$

Where—

2 = Kapp's coefficient for the initial specific magnetic resistance of soft wrought iron (the number 3 to be used if core, etc., be of cast iron).

$\mathbf{L}_m$ = the mean length of field-magnet circuit in inches.

$\mathbf{S}_m$ = sectional area in square inches (at right angles to $\mathbf{L}_m$) of magnet core.

V. Magnetic Resistance of Air Spaces.

The air spaces circuits, $\mathbf{L}_{as}$, $\mathbf{L}_{as}$, have a resistance,

$$\mathbf{R}_{as} = 1440\frac{2\,\mathbf{L}_{as}}{\mathbf{S}_{as}}.$$

Where—

1440 = Kapp's coefficient for the specific magnetic resistance of air and copper when wrought-iron magnets are used (1800 to be used with cast-iron magnet cores and pole-pieces, and 1500 with wrought-iron cores and cast-iron poles).

$\mathbf{L}_{as}$ = depth of each air space in inches (and since there are two spaces, $2\,\mathbf{L}_{as}$ is inserted in the formula).

$\mathbf{S}_{as}$ = sectional area of each air space or surface area of each pole-piece in square inches.

VI. Magnetic Resistance of Armature Core.

The armature core circuits, $\mathbf{L}_a$, $\mathbf{L}_a$, have a magnetic resistance.

$$\mathbf{R}_a = \frac{\mathbf{L}_a}{\mathbf{S}_a}$$

Where—

$\mathbf{L}_a$ = mean average length of armature core magnetic circuit in inches (if there was only but one path instead of two we should have to multiply by the coefficient 2, as in equation IV., but $2\,\frac{\mathbf{L}_a}{2} = \mathbf{L}_a$).

$\mathbf{S}_a$ = cross sectional area of armature core in square inches.
= twice radial depth × length of armature core.

VII. Total Magnetic Resistance.

The total magnetic resistance of the complete magnetic circuit is therefore—

$$\mathbf{R}_m + \mathbf{R}_{as} + \mathbf{R}_a = 2\,\frac{\mathbf{L}_m}{\mathbf{S}_m} + 1440\,\frac{2\,\mathbf{L}_{as}}{\mathbf{S}_{as}} + \frac{\mathbf{L}_a}{\mathbf{S}_a}.$$

VIII. Kapp Lines.*

The total number of Kapp lines, $\mathbf{K}_L$, of magnetic force which pass through the magnet and air space can there-

* A Kapp line is simply = 6,000 C.G.S. magnetic lines. Kapp proposed this unit (see *Journal* Society Telegraph Engineers and Electricians, vol. xv., p. 518, 1886) as a suitable factory unit for dynamo use, on account of the C.G.S. unit being so small; also from the fact that the revolutions of dynamo-armatures are usually reckoned per

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fore be calculated by *dividing* the ampere-turns ($A \times T_{mw}$) on the magnet windings by the total magnetic resistance in the magnetic circuit.

Or,
$$\mathbf{K}_{L,} = \frac{A \times T_{mw}}{\mathbf{R}_m + \mathbf{R}_{as} + \mathbf{R}_a}.$$

i.e.,
$$\mathbf{K}_{L,} = \frac{A \times T_{mw}}{2\frac{\mathbf{L}_m}{\mathbf{S}_m} + 1{,}440\frac{2\,\mathbf{L}_{as}}{\mathbf{S}_{as}} \times \frac{\mathbf{L}_a}{\mathbf{S}_a}}.$$

IX. E.M.F. in Armature.

The E.M.F. developed internally in the armature winding is— $E_a = \mathbf{K}_{L\,a} \times T_{aw} \times N_{ar} \times 10^{-6}$.

Where—

E_a = E.M.F. developed in armature in volts.

$\mathbf{K}_{L_a}$ = Kapp lines which only pass through armature or the useful field.

T_{aw} = turns of armature wires in series (counted all round core).

N_{ar} = number of armature revolutions *per minute*.

Example I.*—Let us now apply the foregoing formulæ to the design of a single field compound dynamo of similar form to that shown in Fig. 2.

Let the dynamo be furnished with a long shunt, and be of 6,400 watts (external power, P_W), when driven at 1,000 revolutions per minute.

First, let us determine the resistance, current, fall of potential in armature and magnets, and percentage loss of power in the armature, shunt, and main field-magnet coils, using the same symbols as before.

Given $E_e = 100$ volts.

$C_e = 64$ amperes.

Resistances.—Then $R_e = \frac{E_e}{C_e} = \frac{100\,v}{64\,a} = 1{\cdot}55$ ohms.

(*To be continued.*)

REPORT ON THE LIGHTING AT BARNET.

At last week's meeting of the Barnet Local Board a report by Mr. W. H. Preece on the subject of the electric lighting of the town, together with one by his assistant (Mr. Probert) on his photometrical testing of the lamps, was considered. Mr. Preece's report was as follows:

W. H. Mansbridge, Esq. London, Feb. 11, 1889.

Dear Sir,—In accordance with the request contained in your letter of the 23rd of January, and with the resolution of the Board passed on the 15th of January, I have pleasure in informing you that I visited Barnet on the 28th ult., in company with Mr. Joel, and inspected the whole of his arrangements there. My assistant, Mr. Probert, an expert in light measurements, visited the locality on the 2nd and 4th inst. ; and I attach his report to me on the result of his photometric measurements. I answer now the several questions you have asked me.

1. *Q.* Are all the 71 lights of 32 c.p. each? If not, of what power are they?—*A.* It will be seen from Mr. Probert's report that the lamps are not all of the candle-power specified.

2. *Q.* Is the machinery now employed capable of supplying the 71 lamps with 32-c.p. light?—*A.* The machinery now employed is capable of supplying 71 lamps with 32-c.p. light.

3. *Q.* Can you give us any data whereby in the future we may determine for ourselves whether we are getting the amount of light stipulated for in the contract?—*A.* It would be difficult to measure the light except by photometric means, which require the services of an expert, but which are not difficult to master.

4. *Q.* Are all the lamps of uniform power?—*A.* The lamps are not by any means of uniform power.

5. *Q.* Would the present machinery be capable of working another 12 or 15 lights?—*A.* The present machinery might be capable of working another 12 or 15 lights; but it would be most impolitic to add more lights without additional apparatus to provide against the possibility of a breakdown.

I consider that it is a great risk to continue the lighting of your roads and streets with the existing apparatus. The whole of the apparatus in the central station worked by the contractor should be duplicated. I am sorry to see that such an interesting experiment as the illumination of your parish has been jeopardised by insufficient means to maintain the light uniform and steady.

(Signed) W. H. Preece.

[Enclosure.]

In submitting the results of my photometric measurements of the electric lamps in the streets of High Barnet, I beg to add that during the two evenings of Feb. 2 and 4 the lights were, in my opinion, all that could be desired. There is, however, a marked variation in the strength of light given out by the lamps tested. This may be due to absorption of light by the thick glass globe which encloses the electric lamp; to atmospheric absorption; to dirt or grease on the globe obscuring a large proportion of the luminous rays; and to the lamp filaments having deteriorated through use. For absorption, etc., I think the measurements might justly be increased 20 per cent. at least to represent the actual candle-power of the lamps; and I have therefore in the annexed table furnished a column which shows the results of 20 per cent. augmentation. With this addition, the average candle-power of the lamps, numbered 1, 10, 22, 33, 37, 42, 44, 48, 53, and 58 is 27¼. The mean candle-power for the electric lamps, as measured photometrically, is 22·71. The gas lamp was found to equal 12·48 standard candles; hence the average illuminating power of the former shows a percentage increase of 40·6 as compared with the latter.

Appended to the report was a table giving the following figures:

Lamps Tested.	Candle-Power.		Candle-power with 20 p. ct. for absorption.
Hadley-green	21·423*	...	25·70
High-street (10th lamp from Hadley-green	36·378	...	43·65
Do. (first lamp from station)	100·000	...	120·00
Do. (junction with Wood-street	105·670†	...	126·82
Park-road	14·450	...	17·34
Manor-road	15·340	...	18·34
Black Horse	25·837	...	31·00
Bells-hill	22·700	...	27·24
Wood-street (top)	14·650	...	17·58
Union-street (second lamp from High-street	22·457	...	27·00
The Avenue (third lamp from Black Horse)	34·269	...	41·123
Salisbury-road	19·563	...	23·475
Gas lamp at top of Barnet Hill, which should be 16 c.p.	12·480	...	14·98

* The contract power of the lamps is 32 candles.

† This was a "Sunbeam" lamp put up for exhibition. It has since been removed, and replaced by an ordinary lamp.

A discussion followed the reading of the reports, the result of which ended in a resolution being carried, "that the contractor be called upon to provide uniform lights of 32 c.p. within 14 days."

PHYSICAL SOCIETY.—Feb. 9.

Annual General Meeting.—Prof. Reinold, President, in the chair.

The reports of the council and treasurer were read and adopted. From the former it appears that the number of members has only slightly increased during the year, due, it is supposed, to the advantages offered by the society not being generally known, and a flyleaf has been prepared giving a short account of the society's objects and procedure, copies of which may be obtained from the secretaries.

During the past year Vol. I., Part I., of "Physical Memoirs Selected and Translated from Foreign Sources," has been printed and issued to members, and translations of important memoirs by Fourier, Hittorf, and Volta are well advanced, and will be published shortly.

The treasurer's report showed the financial position of the society to be very satisfactory.

Owing to the lamented death of Prof. Clausius, a vacancy has occurred in the list of honorary members, to fill which Prof. R. W. Bunsen was nominated by the council and duly elected.

The following gentlemen were elected to form the new council: President, Prof. A. W. Reinold, M.A., F.R.S.; vice-presidents, Dr. E. Atkinson, Prof. W. E. Ayrton, F.R.S., Shelford Bidwell, M.A., LL.D., F.R.S., the Right Hon. Lord Rayleigh, M.A., D.C.L., Sec. R.S.; secretaries, Walter Bailey, M.A., Prof. J. Perry, F.R.S.; Treasurer, Prof. A. W. Rücker, M.A., F.R.S.; demonstrator, C. Vernon Boys, F.R.S.; other members of council, Hon. R. Abercromby, T. H. Blakesley, M.A., M.I.C.E., W. H. Coffin, Conrad W. Cooke, Prof. O. Lodge, D.Sc., F.R.S., Prof. W. Ramsay, Ph.D., F.R.S., W. N. Shaw, M.A., Prof. S. P. Thompson, D.Sc., H. Tomlinson, B.A., C. M. Whipple, D.Sc. Cordial votes of thanks were passed, 1st, to

minute instead of per second, and that British workmen still measure sectional areas in square inches instead of square centimetres as in the C.G.S. system.

The number 6,000 is made up of two terms—viz., 60, which enables revolutions to be counted per minute instead of per second; and 100, to bring down the measurement of the magnetic lines to reasonable numbers; or $\frac{\text{C.G.S. lines}}{60 \times 100} = \frac{\text{C.G.S. lines}}{6{,}000}$. Then, 1 Kapp line = 6,000 C.G.S. lines.

Since there are 6·4514 square centimetres in a square inch,

1 Kapp line per square inch $= \frac{6{,}000}{6{\cdot}4514} = 930$ C.G.S. lines per square centimetre. Consequently, instead of saying 18,600 C.G.S. lines, we simply say 20 Kapp lines or $\left(\frac{18{,}600}{930}\right)$, which gives small numbers more easily expressed and understood by those engaged in dynamo construction; in the same way that for long distances we prefer to measure lengths in miles instead of in yards or in inches. I have not explained how Mr. Kapp arrived at the above constants, or how they agree (for all practical purposes) with Hopkinson's formulæ—viz., that the magnetic resistance of each part of the circuit is proportional to its length, and inversely proportional to the product of its sectional area and magnetic permeability (as found by experiment at a particular magnetic density). We shall endeavour to explain these points in the discussion if an opportunity permits.

* The calculations for example I. were made by Boucher's Calculator, and thus are therefore only approximately true.—A. J.

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the Lords of the Committee of Council on Education for the use of the rooms and apparatus of the Normal School of Science; 2nd, to the council and officers of the society for their services during the past year; and 3rd, to the auditors, Mr. Inwards and Prof. Minchin, for examining the accounts. In returning thanks for the council and officers, the President attributed the great success of their meetings to the indefatigable zeal displayed by the hon. secretaries.

The meeting was then resolved into an ordinary science meeting, at which Mr. James Wimshurst and Mr. Percy W. Sellon were elected members.

Prof. A. S. Herschel, D.C.L., F.R.S., read a paper on "**Physico-Geometrical Models**," and exhibited a collection of geometrical figure models illustrating elementary forms of crystallographical and chemical form constructions. The subject, he said, had suggested itself to him as an important one for study some five years ago, from the possibility which he then discovered of effecting a four-limbed mechanical cycle, similar to a thermodynamic cycle, with a conically-revolving pendulum, the mathematical conditions of whose motion involved the logarithm of the circle radius of the knob's revolution, as a quantity equivalent to entropy in the thermal cycle. The mechanical cycle may be effected as follows: Suppose the pendulum knob to be revolving at velocity V_1, and radius r_1, imagine the controlling force to decrease so that the radius varies from r_1 to r_2, the velocity remaining constant at V_1; then increase the controlling force to its original value and simultaneously impart velocity to the knob to keep the radius constant at r_2, the final velocity being V_2. Next further increase the controlling force so as to cause the radius to decrease to r_2 at velocity V_2, and finally decrease the controlling force to its initial value, simultaneously retarding the knob till the velocity is V_1 at radius r_1. The nett energy concerned in the operations was given as $W = (V_1^2 - V_2^2)$, and where $\phi = \log. \frac{r_1}{r_2}$, and the cycle affords an illustration of transformation of gyratory motion into energy of reverberatory push along the axis. The logarithm, ϕ, is also measured by the area of a hyperbolic sector, and is connected (as was shown) with a sector of the circle which a lamp's conical beam would inscribe upon a square glass screen or plate, dividing a long room of square cross-section into two parts. The conical beam, prolonged through the glass, then traces on the walls beyond hyperbolas, whose sectors, from their summits, are related to the circle's corresponding sectors by a well-known hyperbolocyclic trigonometrical connection. From this mode of constructing the connection, and from a discordance which it shows at the asymptote extremities with Euclid's definition of parallel straight lines, the author concludes that cubic space cannot be continuous in its structure, but must be in a physically constructive sense, like material particles, indestructively atomic or molecular. The models showed modes of constructing cubic space in various ways, chiefly by means of tetrahedra, octahedra, and dodecahedra, the common element of form in these being also shown to be the right-angled tetrahedron, or "biquoin," obtained by dividing a cube into six equal parts by three planes through its diagonals. A model of Sir W. Thomson's soap foam figure, and some wooden models representing Haüy's polyhedral atoms and their combinations, were used to illustrate the structural view thus taken of geometry, and chemical figure models of the ring of tetrahedral carbon molecules in benzene, and of the symmetric groups of similar atoms in active and inactive tartaric acid, were shown.

NEW COMPANIES REGISTERED.

Mines and General Telpher Company, Limited.—This Company has been registered by Messrs. Lee and Pemberton, 44, Lincoln's-inn-fields, W.C., with a capital of £4,000 in shares of £1 each. Object: to construct and work lines for the carriage of minerals and other materials under a license from the United Electrical Engineering Company.

Graphophone Syndicate, Limited.—Registered by Sydney Morse, solicitor, 4, Fenchurch-avenue, E.C., with a capital of £100,000 in shares of £10 each. Object: to acquire the seven British patents taken out by Bell and Painter, with applications for others now pending, and to carry into effect an agreement made between Woodhouse and Rawson, Limited, of the one part, and John Hamilton Ward, as trustee for and on behalf of this Company, of the other part, and Walter T. Glover and Co. of the one part and John Hamilton Ward, as trustee on behalf of this Company, of the other part; to carry on the business of engineers and contractors for the manufacture, supply, sale, exchange, letting on hire of plant, machinery, implements or devices for recording and reproducing sound, recorders, cylinders, etc. The first subscribers are:

	Shares.
F. L. Rawson, 11, Queen Victoria-street, E.C	1
J. H. Ward, 55, Shelgate-road, Wandsworth	1
J. P. St. Quenton, 38, Lee-road, Lee, Kent	1
J. MacFarlan, Invermay, Wimbledon	1
Sir R. W. Rawson, K.C.M.G., C.B., 68, Cornwall-gardens, S.W.	1
Sir F. L. McClintock, 8, Atherstone-terrace, S.W.	1
G. Offor, Peak Hill Villa, Sydenham	1

The number of Directors shall not be less than three nor more than nine, of which one-third shall be nominated by the Volta Graphophone Company of Virginia, United States of America. The first Directors of the Company shall be nominated by the signatories to the memorandum of association. The qualification of a Director shall be the holding in his own right of at least £100 shares in the capital of the Company. The remuneration of the Directors shall be determined in general meeting, but so that in no case shall such remuneration exceed £1,000 per annum.

COMPANIES' MEETINGS.

TELEGRAPH CONSTRUCTION AND MAINTENANCE COMPANY.

The twenty-fifth ordinary general meeting of this Company was held on Tuesday at the offices, Old Broad-street.

Mr. Philip Rawson, who presided, observed that the accounts did not enter largely into details, but it would be very unwise for such a Company as theirs to do so. They were still enabled to recommend a dividend of 20 per cent. for the year. During the past year the factories, both at Greenwich and at the gutta-percha works at Wharf-road, had done a considerable amount of work. About 6,000 miles of telegraph wire had been insulated, including submarine and land lines. Their steamers had repaired the Brazilian Submarine cable in January and August, the German Union cable, and the Heligoland cable. The "Scotia" was also employed for three months in repairing the Direct United States cable. A line was also laid of about 456 miles connecting the Dutch Settlements with Java and Macassar, and the steamer afterwards left this country to connect Java with Western Australia by a cable about 1,000 miles long. That cable had been successfully laid, making now the third line to Australia. A further contract had been entered into for connecting the West African system with the Cape, and the length of cable required was 1,350 miles. The greater part of the cable was manufactured this year, and the vessel would sail with it at the end of this week. This cable commenced from a place called Mossamades, a Portuguese settlement on the West Coast of Africa, and it would when completed be laid to Cape Town. Africa would then be surrounded on all sides by cables. The steamship "Kangaroo," which was chartered by the Italian Government for distilling water in the Red Sea, had been returned to the Company, and had since been sold. Their steamship "Calabria" had been chartered from them on very good terms to make a large number of voyages between Antwerp and the River Plate for emigration purposes. The Company's works at Greenwich and Wharf-road were in excellent working order. To fill the vacancy at the Board caused by the death of Lord Alfred Paget, who assisted them for 18 years, they had appointed Mr. William Shuter, who had been connected with the Company from the beginning. The £150,000 of debentures bearing 6 per cent. had been renewed at 5 per cent. Passing to the balance-sheet, he stated that the debts owing to the Company were perfectly good, and the sundry securities, which figured at the close of the year for £468,641, represented securities which, perhaps, were a little more valuable than the amount stated. The net profit on the year's working was £82,580. He concluded by moving the adoption of the report and the payment of a dividend of £1. 16s. per share, making with the interim dividend £2. 8s. a share, or 20 per cent. for the year.

Mr. George W. Campbell seconded the motion, which was unanimously adopted, and the retiring Directors and Auditors were afterwards reappointed.

SUBMARINE TELEGRAPH COMPANY.

The half-yearly ordinary general meeting of this Company was held on Tuesday at the offices, 2, Throgmorton-avenue, London-wall.

The **Hon. H. R. Brand** presided, and in moving the adoption of the report and accounts said that they showed a progressive business, the main consideration which affected the proprietors being that they had to part with it. Another feature, of a more satisfactory character, was that there was a large sum of money invested in various stocks, upon which, if they took their price at the present time, there was a profit of £28,000 to £30,000. He would give them in as few words as possible all the information in their possession respecting the arrangement with the Government for the transfer of the property of the Company. It might have been reasonably supposed that long before that date the Directors would have been in a position to give the full particulars to the proprietors, but delays were inevitable when international negotiations had to be conducted. He could say, however, that the Board had not been responsible for any delay that had occurred, for they had offered every facility in their power to the Government, and had acquiesced in every suggestion that the Government had made consistently with their not sacrificing the interests committed to their charge. He would ask them to bear in mind that throughout the whole of the negotiations the Board had not been in the position of a free agent. Their hands had been, so to speak, tied. So soon as the Governments concerned—that was to say, the English, French, and Belgian Governments—had decided to take into their own hands and to work the telegraphic system between this country and the Continent, the Company lay under a sentence of death; for not only its rights and authority ceased, but, what was still more important, a considerable portion of their property would have had no value unless it could be transferred to those who were about to conduct the traffic heretofore carried on by the Company. In March of last year they received a letter from the Treasury offering certain terms of purchase, which were generally that the Government would take over the whole of the employés with the exception of seven, as well as the whole of the Company's property at a valuation, save what were known as the Deolin and Salcombe cables. The Directors did not consider that in some respects the terms offered were adequate, but having regard to their position they had no option but to accept them. They, however, urged on the Government that it should reconsider its decision concerning the Deolin and Salcombe cables, and he believed he might say that he had an assurance that there would now be no difficulty in connection with those cables. At a recent date, however, they received information from Her Majesty's Government to the effect that it was under a convention with the French Government either to purchase cables

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or lay them down jointly, and that the French and Belgian Governments had not seen their way to accept the principle of arbitration. The French Government proposed as an alternative course of action that an independent valuation of the cables belonging to the Company should be made by the officials of the French and Belgian Governments, and also by those of the English Government, and that they should have access to the books of the Company. It was very difficult to estimate what the result of that valuation would be; but they had received the most positive assurances, both from the English and French Governments, that they would deal with the Company in a spirit of equity, and he hoped that by the 31st of March all the arrangements would be satisfactorily completed.

The **Hon. Ashley Ponsonby** seconded the motion.

Mr. Soden animadverted upon the action of the Government in bringing pressure to bear on the French Government with the object of not renewing the Company's concession.

The **Chairman**, in reply to questions, pointed out that the Directors could have adopted no other course than they had followed, and that it would have been an act of suicidal folly if they had taken up a position antagonistic to the French and English Governments, who were masters of the situation.

The report was adopted, and the dividend recommended was subsequently declared.

CITY NOTES.

Electric Supply Corporation.—Letters of allotment and regret in the London Electric Supply Corporation have been sent out.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the week ended February 22 amounted to £5,927.

Change of Address.—The Endolithic Ivory Company have removed from 24, Well-street, Jewin-street, to Pomona-buildings, Fore-street, E.C., adjoining Moorgate-street Station.

Lancashire and Cheshire Telephonic Exchange Company, Limited.—An interim dividend at the rate of 7 per cent. per annum has been declared by this Company for the half-year ended December last.

Western and Brazilian Telegraph Company. — The traffic receipts of this Company for the past week, after deducting the fifth gross earnings payable to the London Platino-Brazilian Company, were £4,884.

Stock Exchange.—The Stock Exchange Committee have appointed Tuesday, March 5, a special settling day for Metropolitan Electric Supply Company, Limited, shares Nos. 6,101 to 50,000; the Eastern Telegraph Company, Limited, new ordinary shares, Nos. 380,001 to 400,000. The committee have ordered the following securities to be quoted in the official list: The Eastern Telegraph Company, Limited, 20,000 new ordinary shares, Nos. 380,001 to 400,000; the Metropolitan Electric Supply Company, Limited, shares Nos. 6,101 to 50,000.

Submarine Telegraph Company.—The report of the Directors of the Submarine Telegraph Company, Limited, for the six months ending December 31, 1888, shows a net sum which enables the Directors to add the usual proportion of the receipts to the reserve fund, to recommend a dividend for the half-year at the rate of 16 per cent. per annum, and to carry over a balance of £629. The dividend paid for the corresponding period of 1887 was at the rate of 15½ per cent. per annum. The number of messages transmitted during the six months was 1,846,002, containing 20,328,271 words. In 1887 there were transmitted 1,695,860 messages, containing 18,701,557 words. The average length of messages in 1888 was 11·01 words, against 11·03 words in 1887. The receipts of the half-year show an increase of £3,887 over those of 1887, and the expenses show an increase of £1,283. This increase is stated to be principally caused "by the insertion of much new cable when repairing several of the cables interrupted in the half-year, and by the thorough overhaul and repair of the steamer in the first six months of 1888." The report concludes as follows, no reference being made to the recent allegations as to a hitch in the negotiations with the Governments of England and France: "The proprietors are no doubt aware that the Company's concessions and agreements with the Postmaster-General and with the foreign Governments expired on January 12, 1889. The Directors have to report that the respective Governments agreed to allow the Company to continue working their own cables, as well as those belonging to Her Majesty's Government, until March 31, 1889. No arrangement has yet been definitely arrived at between the Directors and the Government for the acquisition of the Company's property, but considerable progress has been made, and, as the Government has decided to take over the property on April 1, the matter cannot be much longer delayed. The Directors would have been glad to submit for the consideration of this meeting definite terms of agreement with the Government, but at the date of this report they are unable to do so."

PROVISIONAL PATENTS, 1889.

FEBRUARY 18.

2854. **Improvements in electric light fittings.** David Urquhart and William Bates, 6, Westminster-chambers, Victoria-street, S.W.

FEBRUARY 19.

2885. **Improvements in methods and apparatus for charging secondary batteries or electrical accumulators.** Ralph Henry Christopher Nevile, Wellingore Hall, near Grantham.

2906. **Improvements in microtelephonic apparatus, which improvements consist partly in the use and employment of fluids as a medium to impart vibratory motion by means of sound, and currents of electricity.** Robert Henelade Courtenay, 6, Anerley-street, Battersea-park-road, Surrey.

2943. **Improvements in dynamo-electric machines.** Samuel Dickenson Williams, 8, Rutland-place, Newport, Monmouthshire.

2949. **Improvements in galvanic batteries.** Eben D. Cross, 45, Southampton-buildings, London. (Complete specification.)

2952. **Improvements relating to the transmission of electro-magnetic impulses for telegraphic and other purposes.** Henry Harris Lake, 45, Southampton-buildings, London. (Charles Emile Dressler, United States.) (Complete specification.)

2957. **Improvements in underground conduits and insulators for electrical mains.** Alexander Wilson, and Latimer Clark, Muirhead and Co., Limited, 3, Elm-court, Temple, E.C.

FEBRUARY 20.

3022. **An improved telephone mouth-piece.** Rocke Cotterell Greenhill Cottage, Crossmyloof, Glasgow.

3036. **Improvements in electric signalling apparatus for railway trains.** Alfred Julius Boult, 323, High Holborn, Middlesex. (William C. Johnston, junr., United States.) (Complete specification.)

FEBRUARY 21.

3089. **Electrical signalling, self-acting, and otherwise, on a railway.** George Prince and John Watkinson, 27, Albert-terrace, Alexander-road, Burley Fields, Leeds.

3103. **Improvements in electrical measuring instruments.** Walter Hibbert, 8, St. Dundas-road, West Kensington, S.W., London.

3130. **Improvements in or connected with gear wheels and bearings for magneto-electric call-bell apparatus for telephonic instruments, applicable also to other mechanism.** Harry Fraser, 47, Lincoln's-inn-fields, London.

FEBRUARY 22.

3163. **Improvements in electrical call-box apparatus.** Frederick Thomas Schmidt, Sunbridge Chambers, Bradford, Yorkshire.

3213. **Improvements in measuring instruments and electrical appliances.** William Edward Ayrton, 2, Upper Phillimore-gardens, and John Perry, 10, Penywern-road, both in London.

FEBRUARY 22.

3263. **Improvements in the mechanical construction of electrical dynamos.** George Richards, Broadheath, near Manchester.

3272. **Improvements in or relating to electric motors.** William Phillips Thompson, 6, Lord-street, Liverpool. (The Westinghouse Electric Company, United States.)

3273. **Improvements in or relating to dynamo-electric generators.** William Phillips Thompson, 6, Lord-street, Liverpool. (The Westinghouse Electric Company, United States.)

SPECIFICATIONS PUBLISHED.

1888.

1364. **Driving dynamos.** Martin. 6d.

4153. **Regulating secondary current derived from continuous transformers.** King. 8d.

4345. **Distributing electrical energy.** Kapp. 8d.

4604. **Continuous opening and closing of electric circuits.** Pyke and Barnett. 8d.

5182. **Telegraph transmitters.** Stone and Gilfillan. 8d.

5922. **Joining electric conductors.** Stuart. 8d.

14,110. **Telephone central station apparatus.** Vail and Seely. 8d.

14,111. **Telephone exchange signalling.** Vail and Seely. 8d.

15,369. **Secondary batteries.** Fichet and Nodon. 6d.

1889.

30. **Electric telegraphy.** Dewey. 8d.

394. **Telephones.** Johnson. (Gower and Roosevelt.) 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	5/8
27 July	10/0	India Rubber, G. P. & Tel.	10	18¾
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
26 April	4/0	Reuter's	8	7½
......	...	Swan United	3½	8
12 July	12/0	Telegraph Construction ...	12	44
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	13¼

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NOTES.

Madrid.—The defective state of the plant in the Madrid theatres has resulted, it is stated, in the town deciding to authorise a central station.

Forchheim.—A central station for 30 arc lamps is to be erected at Forchheim, in Germany, the power for which will be obtained from the neighbouring river.

Newcastle.—The applications of the two companies applying for licenses have been granted, with a stipulation prohibiting transfer to other companies at a profit.

Telegraphs to Persia and India.—We are informed that the Indo-European Company's communication with Persia and India and the Far East is temporarily interrupted.

Danish Cable.—The submarine cable from Calais to Denmark is at last repaired. The bad weather has obliged the steamer on several occasions to run into the Thames and various Dutch ports for shelter.

Sale.—We have received the catalogue from Messrs. Wheatley Kirk, Price and Goulty of the sale of electrical plant of the "Sun" Works, which is to take place on March 13, on the premises, at 11 a.m.

The Institution.—The next meeting of the Institution will be on March 14, at 8 p.m., when the discussion on Prof. Forbes' paper, "Some Electric Lighting Central Stations in Europe, and their lessons," will be commenced.

Bath.—The resolution of the Urban Authority that the wires should be placed underground, has been referred to the Electric Lighting Committee. Fewer standards will now be required, and these will be provided by the company.

Birmingham Exhibition.—The organisation of the Electrical Exhibition at Birmingham is progressing favourably, and is being well taken up by electrical engineers. The whole of the power for moving machinery will be supplied by means of electric motors.

Piccadilly Electric Railway.—Notice of motion has been given in the House of Commons by Mr. Bensor, Mr. Gainsford Bruce, and Mr. John Kelly, that the Bill empowering the construction of a subway between Piccadilly and Holborn-circus for electrical trains be read a second time that day six months.

Edison's Eyes Injured.—The New York *Mail and Express* states that Mr. T. A. Edison has been badly injured in the eyes by chemicals during an experiment. Colonel Gouraud has received a telegram from Mr. Edison, saying that the accident is not expected to have serious results, and that he is progressing favourably.

Pumping.—Plant has been fitted up whereby a supply of water is raised for Kingscavil-cottages, near Linlithgow, from Kingscavil Quarry, by means of an electric motor, the dynamo generating the current being at a distance of a mile and a quarter. The water is forced to a height of 135ft. to the reservoir, through 600 yards of 2in. pipes.

Portsmouth Harbour.—A new railway platform has been erected at the north railway jetty in Portsmouth Harbour for the Queen's use. The covered platform is 500ft. long, and on Tuesday it was lighted by electricity, the lamps being fed from the dynamo on board the "Victoria and Albert," which was berthed alongside the jetty.

Electric Light at Pekin.—The exhibition of the electric light, during the last few weeks, has been a source of considerable wonder and observation to the natives at Pekin. The light, which is intended for the palace, has been on view in Legation-street, and has attracted crowds of people to see it, including some of the Ministers from the Tsung-li Yamên, and officials from the palace itself.

The Julien Storage Battery.—The Julien Electric Company state that they have over 10,000 accumulators now in actual use by their customers, showing a great development of storage in America. A speciality is made of a 25lb. cell, with a capacity of 400 watts. A large demand for batteries is now arising for storage cars, but the largest number at present have been for electric light stations and installations.

Proposed Electric Railway in India.—Colonel Thomason, R.E. (says the *Indian Engineer*), is busy surveying the country between Naini Tal and the plains, at his own cost, with a view to the construction of an electric railway, for which he considers the available water-power, furnished by the lake, now running to waste, sufficient and to spare, and with which he proposes also irrigating a very fine site now lying idle for want of water.

Incandescent Public Lighting.—The Heisler Company have secured a contract at East Portland, Pacific Coast, in severe competition with the gas company, for 125 lamps of 30 c.p. for lighting the public streets. The circuits are 12 miles in length, and the lighting is pronounced very satisfactory by the Council. This is well on to a total of 20,000 lamps supplied by this company for public and private lighting by 30 c.p. incandescent lamps in American towns.

Town Lighting in France.—Quite a number of small towns in all parts of France have adopted the electric light. The latest addition is the town of Hennebont, Morbihan, the Municipality of which has granted a concession for 30 years to MM. Bonnefant et Cie., electrical engineers. The public lighting will comprise 6 arc lamps and 80 incandescents of 16 c.p.; the inhabitants of the town have also subscribed for 500 other lamps which are to be charged for by meter.

Telegraphic Money Orders.—Mr. Henniker Heaton asked the Postmaster-General whether there was likely to be much further delay in introducing into this country the telegraphic money order system which has been adopted on the Continent and in the Australian colonics. Mr. Raikes said that he was glad to be able to state that he hoped very shortly to announce to the House the date on and from which telegraphic money orders will be introduced by way of experiment in this country.

Launch of the "Peral."—The first trial of Lieutenant Peral's electric submarine vessel took place at San Fernando, near Cadiz, on Wednesday. Thousands of enthusiastic spectators witnessed the experiments. Telegrams state that the vessel worked well on the surface, but that a portion of the machinery became heated, and the tide carried the vessel into shallow water, where she grounded. She was got off, however, and returned to the arsenal. A submarine trial will take place shortly.

Electricity in Newspaper Offices.—Mr. Horace Cox is, we hear, intending to light the new *Field* and *Queen* publishing offices, Bream's-buildings, Chancery-lane, with

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the electric light throughout. To no business is the light more applicable than to that of printing and publishing, and it would be advisable that other newspaper offices should follow his example. When they are also able to realise practically the extreme suitability of the electric motor to printing, our happiness in life will be fairly complete.

Joel and Co.—We learn that business arrangements have been made by Mr. Henry F. Joel with Mr. W. Potter, A.M.I.C.E., who will henceforth work in conjunction with the firm. Mr. Potter takes up his residence at Barnet, presumably to give personal attention on the spot to the pioneer work of incandescent public lighting. Messrs. Joel and Co. have just lighted the Wholesale Co-operative Stores, Leman-street, E., with 200 lights, and have been busy for some time with some pretty extensive electric lighting among the mills in Scotland and the North of England.

Harrow.—Another public meeting was held at Harrow on Thursday, the 28th ult., on the public invitation of Messrs. W. F. and F. Taylor, when a fairly large number of ratepayers attended. Messrs. Taylor expounded their scheme in opposition to Mr. Crompton, and gave details of cost, and representatives of the Westinghouse and the Gaulard-Gibbs system also addressed the meeting. Resolutions were proposed stating that it was advisable that the electric light should be introduced, and the formation of a committee was proposed; but the proceedings became unbusinesslike, and the audience left before a committee could be appointed.

Chicago.—A large central station is now working in Chicago on the Edison system, with 17 miles of underground mains. The station has a capacity of 80,000 16-c.p. lamps, of which 13,000 are now connected. The building has been specially designed by one of the leading architects, and is thoroughly fireproof throughout. There are to be 36 Edison dynamos of 600 amperes, and eight of these are now installed, and in operation. A large amount of current is also disposed of for motive purposes with excellent success, the power being applied to various uses, such as printing presses, elevators, ventilators, pumping, manufacturing, and a large number of miscellaneous industries.

New Wood Casings.—Mr. Samuel Elliott, of the Albert Moulding Mills, Newbury, is again well to the fore with a catalogue of wood casings for electrical contractors, which we should advise our readers to write for, comprising a large and varied assortment of sections of casings, covers, and cleats for electric light wires. These are beaded, grooved, and moulded in shapes either to harmonise with the elaborate wall decorations of mansions or for the simplest factory work. The designs of many of them are arranged so that they can be run as chair-rails round a room, or as ceiling mouldings, omitting the grooves for wires when necessary. The casings are worked in American whitewood, oak, mahogany, teak, walnut, pitch-pine, yellow deal, or other woods as desired.

Memorial to Gaulard.—The Council of the Società Italiana di Elettricità has taken up the proposal embodied in a letter from Sig. Piazzoli to Sig. Bignami, director of the Rivista *L'Elettricità*, to present, in honour of M. Gaulard, some suitable token of the high appreciation in which that gentleman's efforts on behalf of science are held in Italy. In that country the practicability of the useful transmission of electrical energy was first proved in 1884, when the Lanzo station was electrically lighted by energy generated at Turin, 24 miles distant; and it is thought that the encouragement then given by Italy to the new system entitles their representative society to take the initiative in asking subscriptions for the purpose of recording, in the form of a memorial tablet, the perfect success of the early experiments with the secondary generators. Communications or subscriptions may be forwarded to Sig. Wolf, Cassa di Risparmio di Milano.

Halifax Mutual Lighting.—We have several times recommended the adoption of a scheme of mutual benefit for users of electric light and power in various localities, and we are glad to see that Halifax is promising progress in this direction. The Halifax Mutual Electric Lighting and Supply Company, we hear, are in negotiation with the Corporation to obtain their permission to light a large area in the centre of the town with electricity, and to enable them to do this they ask liberty to cross the streets with overhead wires. The company, which is formed largely of gentlemen who intend to use the light on their own premises, has received large support from persons who intend to take the light, and the capital required will, it is understood, be at once subscribed. It is the intention of the company to give all consumers an opportunity of acquiring an interest in the company so that the benefits to be derived may be made as mutual as possible.

A Gas Company's Electric Station.—A very fine specimen of electric light station, undertaken by the local gas company, has been opened at St. Paul's, Minnesota, U.S. The station is run on the Thomson-Houston system, and the engines, which are of the Corliss type, have a capacity of 2,500 h.p. There are four long lines of shafting, carefully arranged, with heavy foundations, one behind the other on the ground floor, fitted up complete with Hill friction-clutch, pulleys, and couplings. The main belts run underneath the flooring and out of the way of the line of shafting. The dynamos are on the second floor, and the friction clutches can be worked from either above or below. The dynamo belts run upwards, and hang on the dynamo pulley, giving the heavier contact on the smaller pulley. The station is a very successful installation, and is a sample of the sort of enterprise on the part of gas companies that we should like to see extend.

Barnet.—The plant at Barnet is being extended by the addition of two 50 actual h.p. Royal Mail type Tangye engines, and two 50-h.p. boilers by Frazers, of Bow. The dynamos will be Joel dynamos. We believe that although Mr. Joel has quietly taken what blame has been given for the difficulties occurring at the opening of the electric light at Barnet, the makers both of the dynamos and the lamps have been largely to blame in the matter, both through inferior workmanship and delay. Mr. Joel alleges that the Bernstein lamps were months overdue in delivery, and were not all of the ordered candle-power; while the Statter dynamos proved very far from satisfactory in their working, and will be discarded. Troubles introduced by the neglect or delay of contracting manufacturers are extremely unfortunate, as there are quite sufficient difficulties to contend with in introducing a new system of lighting into English towns without interior difficulties to deal with.

Control of the Submarine Cables.—In the House of Commons on Monday, in answer to a question by Sir R. Fowler, Mr. Raikes said: I am glad to be able to state

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that the negotiations with the Governments of Germany, Holland, Belgium, and France, which have been in progress for several months past, are now nearing completion, and I have now every reason to hope that the working and the maintenance of the cables between this country and those named will, after an early date, be entirely in the hands of the telegraphic administrations of the five Governments. A uniform rate of 2d. per word with a minimum will be charged—a reduction in the case of Germany and Holland of 1d. a word, and in the case of France of ½d. per word. At the same time, negotiations have been proceeding and are well advanced between the Governments of France, Belgium, and this country for acquiring from the Submarine Telegraph Company the cables now their property between England and Belgium and France, and by the Government of this country for the transfer of the officers of the Submarine Company to the service of the Post Office, and the acquisition of the offices, cable ship, stores, etc., by the Post Office.

Humboldt Electric Power.—The statutory meeting of the Humboldt Electric Power and Mining Company, Limited, was held on the 28th ult., at the offices, 63, New Broad-street, E.C., under the presidency of Sir W. Guyer Hunter, K.C.M.G., M.P. (the chairman of the company), when it was reported that satisfactory progress had been made, and that shares were now being offered at a premium. Mr. Alfred E. Ann, the managing director, in giving particulars as to the working, said that the subject of the employment of electricity for these purposes was attracting a good deal of attention both here and in America, and he believed also in Africa, and the firm from whom they had received the last tender among those referred to by the chairman, had already supplied the great Comstock with an electric system which was said to be working most satisfactorily. The firm in question had tendered for this company's work, and was some thousands of pounds lower than the first tender received. Thus, although they had regretted the delay, they had really saved considerably by waiting. It was hoped, in four or five days, they would be able to cable out the order for the proceedings at the mine to commence. It was found that the distance from the river to the house of Mr. R. K. Colcord, the engineer, was just over 12 miles. They had found there was more water power than they had expected and represented, in the dry season, a gross h.p. of about 460, so that if they only took a quarter of it, it would be plenty for their first operations. He did not think it would be advisable to attempt to crush much ore before electric power was applied. He expected the electric plant would be erected in another month or two.

Electrical Type-setter.—Mr. Samuel Story's "Notes of an American Trip," now appearing in the *Sunderland Echo*, has an interesting account of type-setting by electricity on the *New York Tribune*. He thus describes it: Imagine my surprise when, on entering the composing-room, I found—*no type*. None; except a very limited quantity of large, odd sizes. How, then, is the paper set? By machines—electrical machines. There they stood in a row, 30 grim, silent demons. At the turning of a little handle they are instantaneously full of life. Each has a keyboard like a piano, and in front of the operator a series (105 in number) of oblong tubes like the attenuated reeds of a miniature organ. These hollow tubes are about 2ft. in length, as broad internally as type is high, and with a frontage as large as the type is thick. Each is fitted with brass squares, with a section cut out in a series of slots or nicks. Each letter has its own series of nicks on the inner edges of a V-shaped groove, and a square-edged space at the side where is the matrix or reverse of the letter. The operator, sitting with the copy before him, touches the keys, and each letter falls in due order till the line is complete. Two steel fingers seize this, push it along, space it and justify it. Again two fingers seize it, and push it in front of a little cistern full of molten lead. As it reaches its place, the machine pushes out from the cistern a layer of lead line-long and type-thick. The faces of the cooling lead and the brass edge come into contact, the matrix letters are impressed as positives on the lead, and there remains a solid line of type. This goes in due course to the galley, and the columns and pages are made up and stereotyped in the ordinary way. Meanwhile, the machine whisks the brasses up to a series of little waggons running on an endless wire above the tubes, and as each brass reaches its own nicks it drops into its tube and is ready again for use. It has only been out of its nest one-third of a minute at the utmost. As a consequence, few brasses are needed. The letter oftenest used, e, has only 16. I could carry the whole complement for a machine in my coat-pockets. "And what will a machine perfect?" said I. "One machine, with one man only, will set 5,000 ems an hour," said Mr. Lyman, "and do its own distributing. And there is no waste of type, no wear and tear. It is equal to six men." "Do other papers use it?" "None in New York; a few in the country, where they don't compete with us, and are owned by our friends." "And England?" "None in England *as yet.*"

Public Lighting at Brussels.—The commission appointed in Brussels to consider the question of electric light at its last meeting determined that the installation should not be undertaken by the Municipality out of the rates, but should be the subject of a concession to a private company under regulation from the Municipality, the town to have the right to purchase the installation in any specified time. Propositions for the concession must be received by the 1st of July next. The following are the principal conditions: The undertaking must include the erection of stations, and the running of mains to the houses of the streets, shown on the plan prepared by the Municipality. The service must be available for both electric light and power, but the contractors may choose their own system. They can use either a low-tension system of one or several stations, or a high-tension system of transformers or accumulators, or a combination of these. Ground for low-tension stations could be obtained at 500f. per square metre near the Pavilion Nord and behind the Eden Theatre. If for high-tension currents, grounds at a greater distance can be obtained at a cheaper rate. All the installations must be so arranged that the output could be doubled without further purchase of land, and the sites must therefore be sufficiently large at first. Among the first applications the town will take 120 arcs of 12 amperes for the Boulevards, 600 amperes for the lighting of the Theatre Flamond, and 80 arcs for the Parc and other places. The contractors, among other things, will be required to state how they will ensure a constant difference of electric pressure in the mains; the amount of insulation they guarantee; the method of laying the cables and of making house connections; and the prices to be charged for current. The mains can be laid either under the pavement or the road, or within the large-sized sewers which run down nearly the whole of the principal streets of Brussels and the suburbs. In the boulevards Anspach and du Nord, and

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in the Rue des Fripiers, the mains must be laid down each side. Besides exact details of the charge for current to customers, the tenders must also give the cost of all conduits, wires, fittings, and apparatus necessary for the introduction of the light into private houses. The length of the concession will be strictly limited. Every assistance will be given to the extension of the distribution to the suburbs. The salaries of the officials provided by the contractors will be paid by the town, at a scale not exceeding that indicated in the tender. The contractor himself to direct the management of the undertaking, or to delegate engineers capable of carrying it on. In addition, the book-keeping, and the whole working of the station, is to be subject to the general control of the town for the period of two years.

Arc Lamps.—The clear and ab'e exposition by Prof. Thompson on "Arc Lamps and their Mechanism," at the Society of Arts on Wednesday, was listened to with extreme interest by a very crowded audience, and, as Mr. Percy Sellon remarked at the close, was characteristic of Prof. Thompson's lectures in not being a mere *rechauffé* of old descriptions, but a new grouping, with the enunciation of ideas from which everyone might learn. The division of arc lamps into three groups—namely, the Continental or clockmakers' lamps (rack adjustments), the Yankee or sewing-machine lamps (clutch lamps and others), and the British or engineers' lamps (with mechanical or friction-feed)—was vastly appreciated. Some of the audience testified to the excellence in practice of the so-called sewing-machine lamps, seemingly rough and "thrown together," but which acted admirably in practice. Mr. Preece, who acted as chairman, pointed out, however, that when the streets of the City of London—and probably also the Strand and Piccadilly—were lighted with thousands of arc lamps, something which would act better than those which satisfy a newly-built American city would be required in the first metropolis of the world, and all the ingenuity of lampmakers would be called into play for the production of a perfect lamp. In the lecture Prof. Thompson illustrated and described the older forms of arc lamps, described and showed the Brush, Thomson-Houston, Crompton, Siemens, Fein, and other lamps, and referred with great favour to the Brockie-Pell arc lamp, saying that Mr. Brockie had run the gamut of all arc lamp constructions, and produced finally, with Mr. Pell, a lamp which he thought ought to be far more widely known and used. He also testified to the good working of the lamp (Newton's), in which the feeding is secured by the waggling of a wire scratch-brush, which presses obliquely upon the carbon rod, gradually forcing it downwards. The lamp to which Prof. Thompson gave the greatest praise was a new one devised by Macquaire, now introduced by the Planet Manufacturing Company, 2, Victoria-mansions. This was exhibited, for the first time in England publicly, on the occasion of this lecture, though it has been tested at the Kensington Court station, and its action, as shown by means of an object-glass reflecting the arc upon the scene, gave the nearest approach to a perfect regulation hitherto produced. The lamp really should belong to a fourth category, and be called an electrical engineers' lamp, for the regulation is obtained by the action of a small electric motor, whose field-magnets are the series-coil, and whose armature is the shunt to the current. The action is so arranged that the motor turns one way or the other, according to the dip of a small arm acting upon the brushes of the little motor. The result is an arc lamp working in any direction, feeding by almost infinitesimal portions, practically silent, and maintaining an arc more regular in its formation than even the text-book cuts of the two arc carbons. It is, moreover, having the motor behind it, not open to liability to stick by dirt or friction, as will gravity lamps, and indeed it is difficult when working to hold the carbons apart. We hope to give a full report of Prof. Thompson's paper next week.

Electricity and the New Political Economy.—In the current number of the *Century Magazine* there appears an article by Mr. Charles Barnard, entitled "Something Electricity is Doing," an able exposition to the popular mind of the progress of electric motor engineering. In this article there occurs a passage, with which we are in the heartiest accord, referring to the influence of the motor upon the conditions of life in the future. Mr. Barnard says: "To the student of social science the electric motor is full of suggestions for the future. If power can be subdivided and conveyed to a distance, why may not our present factory system of labour be ultimately completely changed? People are huddled together under one roof because belts and shafts are so pitiably short. If power may traverse a wire, why not take the power to the people's homes, or to smaller and more heathful shops in pleasanter places? To-day we find sewing-women crowded into a hot, stuffy room, close to the noise, smell, dust, and terrible heat of some little steam-engine at one end of the room. The place must be on a low floor because of the weight of the engine and the cost of carrying coal upstairs. Let us see how the work may be done with motors. We may take the elevator in a wholesale clothing warehouse on Bleecker-street and pass through the salesrooms to the top floor. The building is lofty and of light construction, and yet we find in the bright and pleasant attic above the house-tops a hundred girls, each using power. They are seated at long tables, each one having a sewing-machine, and secured to the under side of the table is a small electric motor, one to each machine. The operator has only to touch a foot-pedal and the motor starts, giving about one-tenth of a horse-power, at very high speed. If the speed is too fast, it can be regulated at will by the pressure of the foot on the treadle. There is no heat, no dust or ill-smelling oil, and only a slight humming sound, the sewing-machine itself making more noise than the motor. The room is sweet, clean, and light, and it is in every respect a healthful workroom. If we look out of the window we see two insulated wires passing under the sash down to the electric light wires on the poles below. There are people who cry out against the overhead wires, and would pull them all down. Some day they will be buried underground. Meanwhile, is it not an immense gain for these working girls to be placed in a quiet, sunny room, far from the maddening engine? In another shop on Broadway we may see a different arrangement. A 2 h.p. motor takes its current from an electric light wire in the street, and redistributes its power to shafting placed under the work tables. Each operator with a touch of the foot throws her machine into gear, and takes her share of the 2 h.p." This condition of things admirably illustrates the effect electricity will tend to have upon the life of the workers. We believe, indeed, that the motor arrives just at that juncture when the pressing condition of modern work requires it, and the electric motor, it will be found, in the near future will inevitably create an industrial revolution greater even than that of the introduction of the steam-engine and the rise of the cotton system.

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ELECTRICAL MEASUREMENT.*

BY PROFS. W. E. AYRTON, F.R.S., AND J. PERRY, F.R.S.

(Verbatim report of the abstract of the Paper given by Prof. Ayrton at the meeting.)

(Concluded from page 177.)

For the purpose of ascertaining the exact law of variation of the effect of a layer of wire with its distance from the axis of our ordinary magnifying spring instruments, and the right depth of wire to put on, we had one of these instruments—the one on the table—wound with eight separate layers of copper wire 83 mills. in diameter, covered to 97 mills. Each layer contained the same number of convolutions, and we could send the current through only one layer, or through only two or more layers in series. The various sets of curves which I hold in my hand gives the results of a long series of experiments made with this instrument by Messrs. Fossett, Horne, and Jacob, three of the third year students at the Central Institution. The first set of curves shows the current required to produce any particular deflection when any one of the eight layers is used, the second set when either layer one is used, or layers one and two in series, or layers one to three, one to four, one to five, one to six, one to seven, or all the eight layers; the next set the watts absorbed to produce any particular deflection when the same sets of layers are used, and the interesting result comes out that if all the eight layers be used, it requires the greatest expenditure of watts to produce any particular deflection, whereas if only layers one and two it requires the least expenditure. In this set of experiments layer one alone was not used, as it heated too much when the maximum deflection was being produced. The next set gives the ratio of watts expended to cooling surface of the bobbin if only wound with the particular layers employed in the experiment; and now the results are reversed, for although there is the least expenditure of watts to produce any particular deflection if only layers one and two be used, the ratio of watts to cooling surface is the maximum, whereas for layers one to eight inclusive the ratio of watts to cooling surface is a minimum—in fact, the cooling surface obtained by winding the wire to a greater radial depth increases more rapidly than the watts expended in producing any particular deflection. Hence the increase of radial depth which we effected some time back in our magnifying spring instruments was a beneficial change, since, although it increased the actual expenditure of power, it diminished the rise of temperature of the instrument which occurs when the current is allowed to pass for some time.

The last set of curves is an extremely interesting one, as it led to a result that we were not looking for. In this series the observations of the true value of the current and the corresponding deflection was made with a gradually increasing and then with a gradually decreasing current, and it was found that the percentage difference in the readings for an ascending and a descending current depended on which of the layers of wire were being employed. If the outside layers were used the residual magnetism error was less than if the current was sent through the inside one. I suppose that was due to the fact that the residual magnetism of the iron tended to send its lines of force in one direction, while the current when flowing in a coil of large diameter would send them in a somewhat different direction; but there was no doubt of the fact that we got a different amount of residual magnetism error when different layers were employed: the instrument was better, in fact, when used with certain layers than when used with other layers. The general conclusion was that the permanent magnetism error for an ascending and descending current was the greatest when layers one to five, nearest the core were used, less when layers one and two were used, still less when layers one to eight were employed, and the minimum error was obtained when the current passed only through the outside layers, seven and eight. It seems to be a question of the difference between the shape of the field due to the coils, and the shape of the field due to the residual magnetism in the iron.

* Paper read at the Physical Society, February 23, 1889. Prof. Reinold, F.R.S., in the chair.

But whatever the explanation may be, the important fact remains that *the permanent magnetism error of a given piece of iron, when used in a measuring instrument, can be varied in amount by varying the diameter of the coil.*

STANDARD INSTRUMENT OF WIDE RANGE.

The next point, perhaps, that has to be considered is what is the best way to make for a laboratory a cheap arrangement which will measure very accurately a very large range of currents. Of course, Thomson standard instruments can be bought for measuring from one small fraction of an ampere to some other fraction, and so on. But suppose a laboratory wants to measure with considerable accuracy currents from ·01 to 600 amperes, how can it be done? One way is to purchase a dozen standard measuring instruments, costing perhaps two or three hundred pounds. But suppose the funds do not allow of such a great expenditure, how can the same result be obtained? It can be obtained in a very simple, and certainly far cheaper, way; and the plan that we adopt at the Central Institution is to use a voltmeter with a wide range of variable sensibility to indirectly measure currents. We send the current to be measured through a fairly large and thick sheet of platinoid, such as the sheet before you, which is the substance having the smallest temperature coefficient: we are now using leaves of platinoid parallel with one another so as to get still great surface. We assume that the currents are such as not to alter the resistance of the sheet by any appreciable amount. The instrument used is, as I have said, really a voltmeter, which is attached to two fixed points by means of wires soldered to two definite points of the platinoid, and the voltmeter we employ is a d'Arsonval galvanometer, by which the difference of potential between two fixed points in the platinoid is measured, and you see that by altering the resistance in the voltmeter circuit you obtain an enormous range of sensibility. If the instrument is calibrated so that when it alone is a shunt to the sheet of platinoid, one ampere gives a deflection right across the scale of 600 divisions, then by inserting known resistance the sensibility of the instrument is at once diminished in any definite ratio we like without any other absolute calibration being necessary, assuming that the platinoid does not change its resistance by the passage of the current. It is by that means possible to obtain a complete deflection right across the scale for one ampere, or for some hundreds of amperes, or for anything between; and if you want to measure 1, 10, or 50 amperes to $\frac{1}{500}$th, it is done by the introduction of a known resistance, and the sensibilty is at once changed in a certain definite ratio. The d'Arsonval coil is not heated by the passage of the current. At first we were desirous of making direct-reading scales to be used with large range of current, and of making the arrangement such that, instead of having to calculate what 100 divisions meant, a new scale could be put in place of the old scale, and the current could then be at once read off in amperes, milliamperes, deca-amperes, or deciamperes corresponding to the different resistance put in. But the difficulty we met with was that with the ordinary d'Arsonval galvanometer, the deflections, in spite of the very small angle through which the coil moves, are not proportional to the current. If you start from the centre so that the plane of the coil is along the lines of force when no current is passing, the deflection is proportional to the current; but if you start with the coil deflected, so that the spot of light is at one extreme end of the scale for no current, you find, on carefully calibrating the instrument, that you get a broken straight line consisting of two straight lines meeting at an angle, or, probably, strictly, meeting according to some curve at about the spot corresponding with the plane of the coil, being parallel to the lines of force. Hence there is a difficulty in subdividing the scale uniformly, and this difficulty is met with even when the plan, as proposed some six years ago, of using curved pole pieces is employed. This puzzled us for a very long time. It occurred to us that the effect might be due to the torsional wires being so placed in the ordinary d'Arsonval instruments that there is practically no twist in them when the plane of the coil is along the lines of force and the spot of light is in the middle of the scale. In order to send the spot of light to one end, the top or the bottom

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suspension has to be turned, and as in the ordinary d'Arsonval galvanometers the bottom suspension cannot be twisted round, the spot of light is brought to the end of the scale for zero current by turning the top suspension through twice the angle turned through by the coil. Hence, at the new position at one end of the scale both the bottom and the top suspensions have a twist in them in opposite directions, of an amount equal to the angle through which the coil has been turned from the symmetrical position. Now, we thought that the calibration curve, being a broken straight line, might in some extraordinary way be due to the fact that under these circumstances, when the coil passed through the zero position, the direction of twist on the bottom suspension became reversed, but neither theory nor a number of experiments bore out this idea, which had to be abandoned, and, finally, we arrived at the conclusion that the peculiar result was due to the centre of gravity of the coil not being exactly in the axis of suspension. Hence, the coil was taken down and more accurately resuspended by Mr. Smith, a fourth-year student at the Central Institution. But we found, no matter how accurately he balanced the coil, the break in the calibration curve could not be entirely removed. Finally, however, after much experimenting, our assistant, Mr. Bourne, to whose dexterity of hand and fertility of resource we are much indebted, solved the problem by suspending the coil by a single torsional suspension from the top, and arranging an extremely elastic non-directive suspension to lead out the current from the coil at the bottom; in fact, by obtaining practically a unifilar torsional suspension, at the end of which the coil hangs freely, with its centre of gravity strictly in the axis of suspension, he solved the problem. The result is that *the calibration curve of a d'Arsonval galvanometer so constructed and drawn to such a scale that it is about a yard long, fails to show any want of deviation from perfect straightness when tested by one of Sir William Thomson's balances, and when the length of the scale over which the spot of light of the d'Arsonval moves is about a yard long, subdivided into about 800 divisions.*

Time will not permit of my explaining to you the exact arrangements we have carried out at the Acme Works for rendering the change of sensibility perfectly automatic, so that it is impossible for the tester to be using a different sensibility from the one he believes he is using. Suffice it to say that currents varying from a fraction of an ampere up to 600 amperes, and P.Ds. from a fraction of a volt up to 500 volts, are all measured with one single instrument, and in no case, even for the smallest current or the smallest P.D. to be determined, is the deflection of the spot of light from the zero less than about 4½in.

For determining the absolute value of the deflection in amperes, we have usually employed the silver voltameter in the form recommended by Lord Rayleigh, the current density being limited to one ampere per six square inches of surface of the platinum bowl on which the silver was deposited. At first the results were not perfectly in accordance with one another, but this Messrs. Lamb and Smith, two of our students, who took up the investigation in a most praiseworthy manner, traced to the use of methylated alcohol and methylated ether for the drying of the platinum bowl after the silver was deposited in it. If the bowl was dried in a vacuum after the deposit of silver in it had been washed with distilled water, consistent results were obtained, and they found that equally consistent determinations could also be made by the employment of absolute alcohol without the use of a vacuum. After our d'Arsonval galvanometer had been finally calibrated, Prof. Rücker was so kind as to lend us one of Sir William Thomson's deci-ampere balances, and we found that a certain current measured by it was 4·708 amperes, whereas measured by our d'Arsonval it was 4·699, the difference being only one-fifth per cent. The result is interesting, as we understand that Sir William Thomson's balances are calibrated entirely with the copper voltameter, whereas the calibration of our standard d'Arsonval has been effected solely with the use of the silver voltameter.

Having arranged the d'Arsonval galvanometer so that we knew exactly the connection between the deflection and the current producing it, we observed, on comparing the readings of a Siemens dynamometer with the readings of the d'Arsonval, that the square root of the angle through which the spring of the Siemens dynamometer had to be twisted to bring the moving coil to the sighted position was not perfectly proportional to the current. As the spring of the Siemens dynamometer has some 50 convolutions, we could not at first imagine that the couple required to produce only one-half or three-quarters of one revolution was not proportional to the angle, and we felt that there must be some mistake in the experiment, such as the existence of some permanent field acting on the moving coil, and which would produce a couple proportional to the current, in addition to the action of the stationary coil on the fixed coil, which produces a force proportional to the square of the current. But as we obtained the same result with the Siemens dynamometer on reversing the direction of the current through it, there was no doubt that we had really placed it, as we had intended doing, in such a position that the plane of the moving coil when in the sighted position was perpendicular to the magnetic meridian at the place, and hence there could be no couple introduced by any permanent field. We had been under the impression that whereas the Siemens dynamometer, being a zero instrument, was not so convenient to employ as a direct reading instrument like our magnifying spring ammeter, which can be read from a distance, yet that the disadvantages of having to adjust this zero instrument for each current to be measured was compensated for by there being a perfectly exact simple law connecting the current with the angle through which the torsion head had to be turned to bring the moving coil to the sighted point, and it was not until Prof. Rücker was so kind as to lend us two of Sir William Thomson's meters that we felt quite sure that the small error of the Siemens dynamometer, which we felt our experiments had brought to light, had a real existence. We are most sorry to find that our conclusion is correct, and that the ratio of current to square root of the deflection of the dynamometer, or what is simply called the constant of the instrument, is not absolutely constant, but increases as the current is increased, due, we imagine, to a slight distortion of the spring, which occurs with a deflection of even 180deg.

We have tested five Siemens dynamometers, and find that in all cases the constant increases with the deflection up to a deflection of about 270, corresponding with 243deg. In some cases the constant appears to still further increase as the deflection increases. In others it appears to reach a maximum at somewhere about 240deg., and then to diminish again as the deflection is increased up to 360deg. The fact that the variation of the constant is regular, and not vaguely too high or too low, tends to prove that the result is not due to errors of observation. We append the results of the tests of two dynamometers to indicate the character of the result. Of course, this variation of the constant does not in any way prevent this instrument being of great service, especially for the measurement of alternate currents, but its existence should not be forgotten in the most accurate use of the instrument.

One Dynamometer.		Another Dynamometer.	
Deflection.	$\frac{\text{Current}}{\sqrt{\text{Deflection.}}}$	Deflection.	$\frac{\text{Current}}{\sqrt{\text{Deflection.}}}$
70	1·455	21·5	1·080
132	1·463	54·3	1·085
156	1·470	121·2	1·090
196	1·471	188·7	1·092
234	1·472	270·5	1·095
272	1·478	334·5	1·093
		406	1·091

In each case a deflection of 400 corresponds with a rotation of the milled head through 360deg.

Hot Wire Voltmeter.

I, lastly, come to another point which is also of considerable scientific interest. At the end of 1887 we brought before the Society of Telegraph Engineers a modification of the well-known Cardew voltmeter, which, as you are aware, can be used to measure either a direct or an alternate P.D. Our modification is a very simple one; instead of measuring the actual extension of a straight wire, as Captain Cardew has done, we measure the change of sag of the wire

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by using one of our magnifying springs. Here is one of our instruments. The sensibility of the arrangement is very great indeed. What is measured is the change of sag in the wire, and you can see how very marked is the deflection by putting on two volts.

[Model voltmeter, with a magnifying spring attached to the centre of a wire fastened at both ends, shown in action. A potential difference of two volts applied at the terminals produced a rotation of the pointer through eight right angles.]

Length of Platinum Silver Wire 208 millimetres.

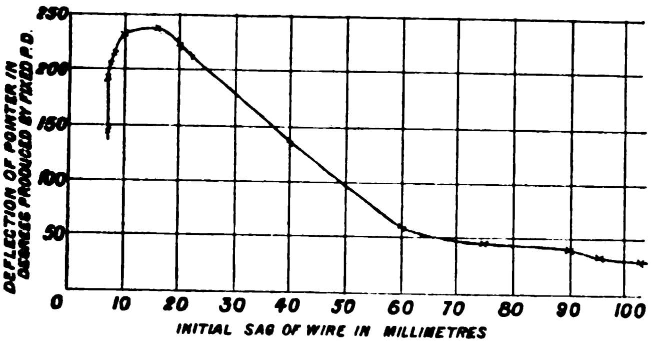

FIG. 1.—Experimental Hot-Wire Voltmeter.

At the time our hot-wire voltmeter was first shown we described what we believed to be the mathematical theory of its working, and it is in connection with that theory that we bring the instrument before you to-day. In our original paper, printed in the *Journal* of the Society of Telegraph Engineers, in which we gave the formula connecting the deflection of the instrument with the volts required to produce the deflection, we gave a calibration curve, determined theoretically, connecting the deflection with the volts required to produce the deflection. But we neglected the variation in the length of the fine platinum wire due to the alteration of stress as the sag altered—*i.e.*, we assumed that the wire expanded simply because it was heated, and we did not take into account the fact that when it expands and gets longer the stress is altered, and therefore the length of the wire is altered. This omission is the more curious since one of us had pointed out in the *Electrician* some months previously to that, that while the cooling of the telegraph wire in the winter diminished the length, and therefore the dip, the increase of stress caused an expansion, so that the whole change of sag in a telegraph wire which occurred with a change of temperature was not as much as it would have been had this change of stress not taken place, and we showed that this compensating effect enabled less sag to be used on telegraph wires in the summer than would be otherwise possible without the wires being broken in the winter.

We were under the impression, however, that the actual stress in the platinum silver wire in our hot-wire voltmeters was not sufficient to introduce a change in their sensibility in consequence of the alteration of stress that occurs with alteration of sag. Experience, however, has since shown that that is not the case, and that when the wire gets hot and expands, and the dip increases, the diminution of stress actually allows, as it were, a contraction of the wire, or, in other words, it does not expand as much as it would were there not this compensating action. This compensating action, which is very valuable to the telegraph-engineer, has the very opposite character for the constructors of our voltmeters, because it tends to diminish their sensibility. Mr. Bourne has made experiments, using the apparatus before you, in which there is a given wire, 208 millimetres long, fixed between two points, a given spring and pointer, but in which the amount of sag can be varied at will by simply moving these two arms; the wire remains the same in length, but the initial sag can be altered; the instrument is covered up, with the metallic cover to shield it from draught of air, and its calibration obtained. He also made experiments of the alteration of sensibility with sag for various magnifying springs and for various initial stresses in the spring, because, as the modification of our original result is due to the alteration of stress with alteration of sag, this modification will be different dependent on the initial stress on the wire. A number of curves are obtained, of which one is shown in Fig. 1, giving the law of alteration of sensibility with initial sag. From these it is seen that, instead of the maximum deflection being obtained for a given P.D. at the terminals of the wire when the initial sag is very small, the sensibility of the instrument rapidly increases as the sag increases up to a certain value, and then diminishes, but less rapidly, as the initial sag is increased. For each type of magnifying spring, and for a given initial stress given to the spring, he obtained a perfectly definite curve giving

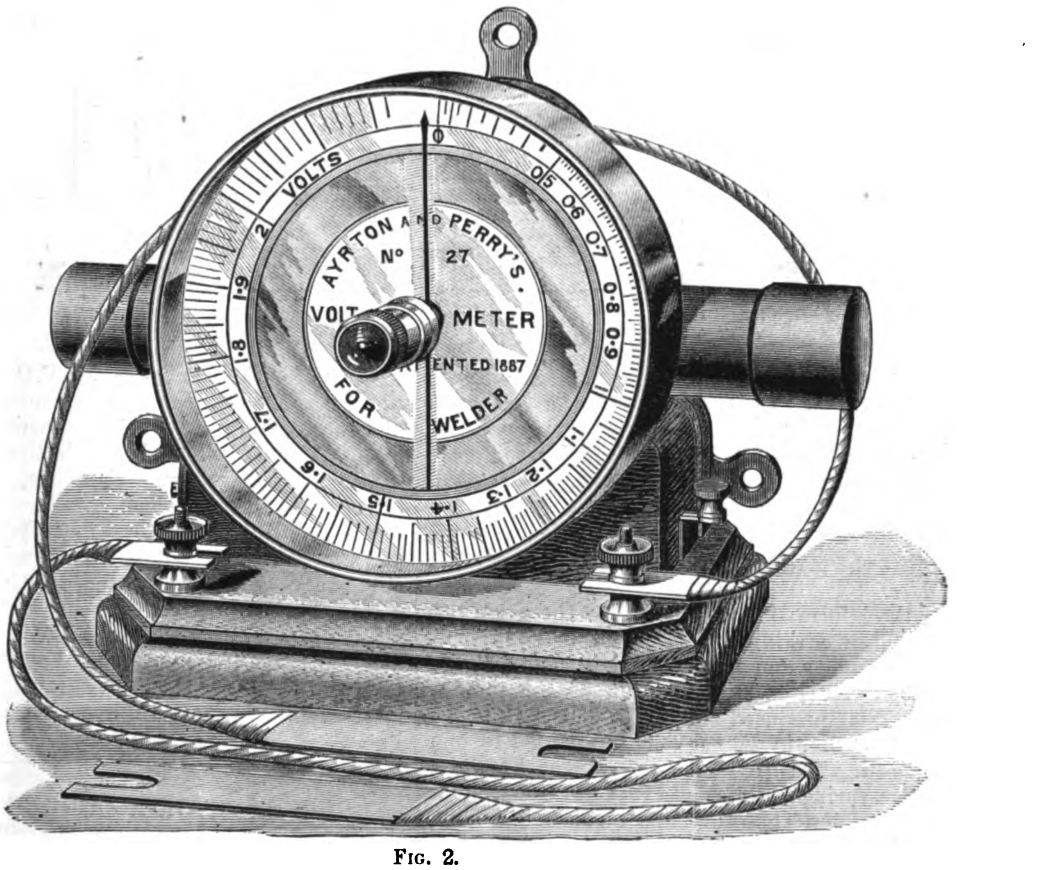

FIG. 2.

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a maximum sensibility with a particular inital sag. These curves have the greatest practical value, because they show what initial sag should be given to the wire to obtain maximum sensibility; also what range is available for adjusting the sensibility of the voltmeter to adapt it to the direct reading scale by altering the amount of the sag.

Another thing came out regarding the temperature correction. Each hot-wire voltmeter should be so constructed that the zero does not alter when the temperature of the whole instrument is changed between the day and the night, or between the winter and the summer; also that a given P.D. produces the same deflection of the pointer whatever the temperature of the instrument as a whole. The tube, therefore, has to be composed of two metals, but the curious thing comes out that the coefficient of expansion of the tube, to get perfect temperature compensation, depends on the initial sag. That is rather an advantage, because it enables us to adjust for zero temperature error. We use iron and copper in the tube in such proportions that the temperature error of the voltmeter is very small, but by a very small adjustment of the sag we can get a temperature error practically nought. That is a most interesting result, and one not foreshadowed in our original paper. During the past year we have again attacked the problem mathematically, taking it up where we left it in 1887; and by introducing the change of length of the fine platinum silver wire that occurs with change of stress, as well as the change of length that occurs with change of temperature, we have obtained formulæ that give results closely agreeing with those obtained experimentally by Mr. Bourne. Time does not allow of my going into the details of the mathematical reasoning, but the members will have an opportunity of criticising it when it appears in print. If the lamented founder of the Physical Society were still amongst us he would, I know, have chuckled at a result being obtained mathematically after it had been arrived at experimentally. But such a sequence shows, of course, not that mathematical conclusions are useless, but only how careful one ought to be that the mathematical data exactly represent the physical data.

By utilising the information taught us by these curves, we have succeeded in making hot-wire voltmeters of surprisingly large sensibility and small temperature error. In the one in front of you (Fig. 2), a rotation of the pointer through 360deg. is produced by 2·16 volts, and the scale, which is about 6in. in diameter, is subdivided to one hundredth of a volt. This particular instrument has been constructed for measuring the alternate P.D. at the terminals of the secondary coil of a Thomson-Houston electric welder, such as the one before you, and which experiment shows is under 2 volts, and which has to be measured when determining the efficiency of the welder. As, however, the absence of an alternate current prevents my showing you the welder in action, we will demonstrate the extreme sensibility of this voltmeter by using it to measure the E.M.F. of this accumulator, and the fall of the P.D. when the accumulator is sending a current. The E.M.F. of the accumulator the voltmeter shows is 2·07 volts. I now cause it to send 10 amperes as measured by this ordinary magnifying spring ammeter, and the P.D., as measured by the voltmeter, falls to 2·03 volts. The resistance of the accumulator is then

$$\frac{2·07 - 2·03}{10} \text{ or } 0·004 \text{ ohm.}$$

A result which this very sensitive voltmeter enables me to obtain almost instantaneously.

Fig. 3 shows a horizontal section of the instrument as at present constructed by the Acme Works. In the original instrument the pull of the magnifying spring, M, was counterbalanced by the pull of the platinum silver wire, W W, attached to the blocks, B B; but to save space both these pulls in the present instruments act on the same direction, and are counterbalanced by the flat spring, M. Hence, as the wire stretches, the magnifying spring, M, is stretched, and the pointer, P P, to which a number of fine hairs are attached to introduce damping without solid friction, rotates. This flat spring is not only introduced to enable the depth of the instrument to be diminished by twice the sag of the wire, but to enable us to introduce a particular form of fuse. In the ordinary Cardew instrument, with its two yards length of wire, the introduction of a short fuse, which will melt with a current too small to damage the instrument, does not seriously increase the resistance, or diminish the sensibility, but in our instrument, which contains only 8in. of wire, the introduction of such a fuse would diminish the sensibility; and if we attempt to diminish the length of the fuse wire in the same proportion as we have diminished the length of the working wire, the conduction of heat from the metallic blocks to which it is soldered is so great that the fuse does not melt. We therefore employ a fuse, F, of such a diameter that it would require a far larger current to melt it than would damage the instrument, but, in addition, we arrange a platinum tipped screw, D, so that when the wire, W W, is stretched by any prearranged percentage beyond the amount it stretches for the maximum safe P.D. the platinum tip, C, of the flat spring, S, comes into contact with the screw, D, and the working wire is short-circuited. The circuit is then temporarily completed through the lead, L, to the left, the flat spring, S, and the fuse, F, when the current increases and the fuse melts without damage to the instrument. With this device we find that the fuse may be thick, and therefore have but a small resistance compared with that of the working wire, and yet the sudden application of a P.D. five or six times as great as the maximum P.D. the voltmeter is intended to measure melts the fuse without damaging the working wire. For clearness, the fuse, the key, and the terminals, V, V, are shown detached from the instrument, but these are in reality in the base, as seen in Fig. 2.

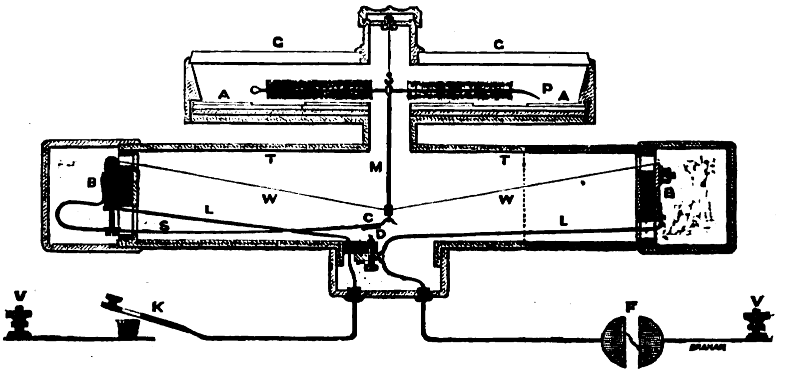

Fig. 3.—Horizontal Section of Hot-Wire Voltmeter.

CABLE REPAIRING UNDER DIFFICULTIES.

A neat bit of cable repairing under difficulties has just been achieved by Mr. Herbert L. Webb, at Cadiz, which we fancy will be found almost as interesting in its way as the finding of a deep-sea cable in 10,000 fathoms. Mr. Herbert Webb, with his friend Mr. Wilson, have constituted themselves into an electrical firm at Xerez, and do a good deal of work for the Spanish National Submarine Telegraph Company. The cable repaired is some few miles long, running to the opposite shore, in comparatively shallow water, of course, and had been broken by a steamer anchoring over it. The feat of repairing the break was accomplished by Mr. Webb with what accessories he could obtain, without cable-ship, and with his own hands. We give the account in his own words, taken from a letter home.

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"I had a good deal of work over that cable job. On the Wednesday I went off at 6.30 a.m. to the dock, and they dispatched a pilot and some men to up anchor and move the ship that had the cable under her chain. I had been over the day before and had made a scratch repairing-ship of an iron raft, on which I had mounted an empty drum and a bow sheave, so as to be able to pick up and relay the piece of cable that had been dragged out seawards. We started off in the launch to look for the buoys, and found they had both sunk; so we grappled the Cadiz side and buoyed the end with a piece of cork, then made for the other side, and a tremendous squall came on with torrents of rain. We grappled the dock side again and buoyed the bight, but could do no work on account of the weather, and set out for the dock—drenched. The following day it was fine, and in the evening they notified me that the ship had been moved; so Friday morning early I was off to the dock. Found no steam was up in the launch, so put in time cleaning jointers' tools. At about nine we started off, towing my "cable-ship," which we moored to one of the iron buoys marking the line of the cable. Made for the cork buoy on the bight dock side and found it alongside a big steamer, which had one anchor down on each side of the cable, so we could not underrun. Dragged to seaward of the steamer, and grappled cable first shot. Underrun to end, which brought us quite close to our cork buoy on the other end, to my delight. We hauled on the piece that we had underrun, and coiled some of it on board. The launch then heaved up the other end and got it on board, made the dock end fast and heaved in on the other, gradually paying out on the dock side as the strain got heavy, and by this means picked up all the slack to the damaged part, where it had got twisted round the anchor that broke it. In this way we got the cable quite straight between the two mark buoys, and picked up all the slack we paid out at the time of laying, when we anchored to make the splice, and wasted some cable when we started getting the vessel on her proper course again. Then we put stoppers on both sides and cut out the damaged piece, and proceeded to joint and splice. My joint was not a very workmanlike affair and would have given a jointer a fit, but my hands were very dirty from helping the men (one can't very well be engineer-in-chief, cable hand, and jointer too), and there were various other difficulties, but I think it will keep out the water all right. The splice, too, was a difficult job, as the steel wires are very difficult to work with no tools and such a small space (the bows of the launch), but we made a good strong one, and lowered it over, and cut both the stoppers in true deep-sea fashion. We finished about one, so you see I made short work of it when once I had a fair chance. It was a lovely calm day. We set out for the dock and had breakfast, and spoke the office all right."

CORRESPONDENCE.

UNDERGROUND MAINS.

To the Editor of The Electrical Engineer.

Sir,—I have perused Mr. R. S. Erskine's letter in your last issue, and I regret to hear that he considers that his company is likely to suffer from there being two electric light stations in Kensington—viz., that of his company, known as the Kensington Court, and that of my company, known as the Kensington Central.

I take the opportunity of pointing out to you the following considerations, which bear upon this question:

1. The Vestry of Kensington has mapped out the parish of Kensington, and very carefully allocated certain districts to certain companies, so that it is impossible for my company to carry its mains into the district served by the Kensington Court Company, and it is equally impossible for the Kensington Court Company to brings its mains into the district alloted to us, so that I cannot see where confusion can arise.

2. In the event of customers in the Kensington Court district applying to us, it is clearly out of our power to supply them, and all we can do is to refer them to Mr. Erskine's company, and if he adopts the same procedure with customers applying to his company for light in our district, we can mutually work Kensington without trespassing upon one another's business.

3. Mr. Erskine points out that the Board of Trade have not yet sanctioned the license which is before them in favour of our company; and then he complains that we have up to the present time done no lighting in Kensington. No one is better aware than he is himself that until the Board of Trade's sanction is obtained no extensive lighting can be done, and that in the meantime we are limited to supplying the streets belonging to private persons where we have laid the mains without having to apply to the Board of Trade for its consent.

4. Mr. Erskine again draws attention to the fact that my company claims to have erected "*the first station which has been completed in the metropolis for the accomplishment of house-to-house electric lighting throughout an extended area by means of underground mains.*" My managing director, Mr. Robert Hammond, has pointed out to Mr. Erskine in *The Times* and elsewhere that Mr. Erskine's intimation that this company has done satisfactory work over a small area by means of underground mains is no refutation of the claim made by the House-to-House Electric Light Supply Company, Limited, that its station at Kensington is the first station completed in the metropolis designed to cope with electric lighting over an *extended area* by means of *underground mains.* The fact that Mr. Erskine's company has laid down a second station at Knightsbridge within a short distance of the first station, proves that from the first station his company is not able to cope with an extended area.

5. Mr. Erskine is well aware by what authority my company is supplying a portion of Kensington, and he is also well aware that the Vestry have sanctioned the application of my company to the Board of Trade for a provisional order covering a much more extended area than the one we are at present dealing with.

6. The station of my company has been called the Kensington Central Station, because it has been erected within the parish of Kensington, and is designed to supply a considerable portion of that parish with the electric light, and though we started by calling it the West Brompton Station we found that name did not sufficiently appeal to the householders of Kensington, to whom we were offering the light.

Yours, etc., H. St. John Winkworth.

House-to-House Electric Light Supply Company,
London, E.C., March 5, 1889.

PROPOSED HARROW LIGHTING.

We have received a long letter from Messrs. Taylor in reply to Mr. Crompton and Mr. Hayward. That portion of the letter dealing with Mr. Hayward is of very slight interest to our readers. The main drift of the argument is, that Mr. Hayward is wrong and Messrs. Taylor right. We cannot enter into details for appointments of committees, dates, etc., but record the fact that the difference exists. The following is the portion of the letter dealing with Mr. Crompton's remarks:

"Mr. Crompton's reply to our strictures is so courteous as almost to disarm criticism. Nevertheless, leaving aside all questions purely controversial, we may express our astonishment that so skilled an engineer as Mr. Crompton should propose to use the boilers of the disused Harrow Water Works to steam his engines. The boilers were in use some thirty years, and have lain idle, half full of scale, for the last three. The pressure gauges being only marked up to 100lb. show that they could only have been constructed for the low-pressure engines in use for pumping water. The engineers of the Westinghouse Company and of the National Company (as well as our own engineer) have inspected the boilers and have pronounced them unfit for use. Mr. Hayward, as a master in Harrow School, ought most assuredly to have informed Mr. Crompton that the Harrow School Laundry Company also surveyed these boilers some short time back, and were unable to use them owing to their wretched condition. We are at a loss to understand how Mr. Crompton expects to get into these boilers a head of steam sufficient to work compound engines economically, or even at all."

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THE

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

DISTRIBUTION BY TRANSFORMERS.

The result of the appeal concerning the Gaulard-Gibbs' patent, as will be seen from another column, is to invalidate that patent. It is unnecessary for us to discuss the terms or the reasons of the judges' decision; they are given fully in the judgment. We have, in consideration of the interests of our readers, to put them into possession of facts concerning what seems to be now the master patent, so that they may consider their ways and be wise. Let us, in the first place, pay a tribute of praise to the value of Gaulard-Gibbs' work. These gentlemen believed in themselves and in their hobby when most other people were sceptical. Their persistence gradually assisted to break down opposition, and compelled people to look into and acknowledge the merits of a system they were at first blush disposed to condemn. While, however, agreeing with the high value usually placed upon the work of Gaulard-Gibbs, we must not lose sight of the fact that a previous worker had shown as thorough a knowledge of the subject as could be shown at the time and under the then existing conditions, while another, almost contemporaneous with Gaulard-Gibbs, has been somewhat overlooked. The latter gentleman, Rankin Kennedy, of Glasgow, was, perhaps, the first to make a systematic examination of the capabilities of transformers. His writings in our contemporary, the *Electrical Review*, formed the first literary work upon the subject, and presented it in a manner "understanded of the people." He not only preached, but he practised, so that his conclusions carried great weight. But before all these came Paul Jablochkoff, who, in a patent dated May 2, 1877, described this method of distribution. It must be remembered that in 1877 the era of electrical progress had hardly commenced. Neither arc nor incandescent lighting were known, or if arc lighting was known to a few it was unknown in a commercial sense, and incandescent lighting "was not." The following year—viz., 1878, the year of the French International Exhibition—the Jablochkoff lamp illumined some of the streets of Paris, and the world began to realise that electric lighting was possible. The veterans who remember this time will recollect the battles-royal about "division"—how, on the one hand, a strong opposition urged the impossibility of divisibility, while, on the other hand, a few laughed at the mere notion of its being impossible. The incandescent lamp appeared on the scene, and settled all controversy as to divisibility. It is necessary to refer to the knowledge of the subject as it then was, to show how far in advance of the moment was Paul Jablochkoff. On the 23rd May, 1879, Sir Wm. Thomson, before the Select Committee on lighting by electricity, gave an answer to question 1783: "But the ordinary methods, of which we have heard, of dividing the light, do not seem to

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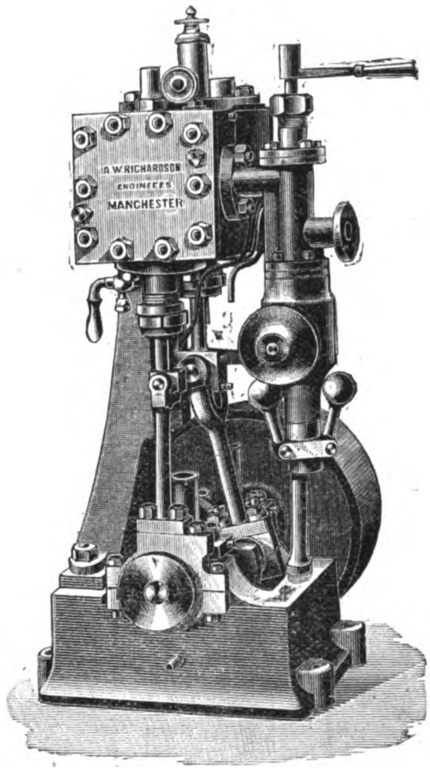
be very much advanced, except in the case of the Jablochkoff candle?" "No, I believe that is the most advanced subdivision of the electric light which we yet have." This answer, as we say, determines the position of our knowledge prior to May, 1879. On referring to Jablochkoff's specification, p. 4, line 25, we read: "In this case the total system of distribution may consist of a central circuit, represented by the series of internal wires of the coils, from which branch out as many distinct conductors as there are bobbins in the circuit. Each lamp is therefore perfectly independent, and may be lit or extinguished separately. The distribution of electricity in a building to be illuminated is in this case similar to the distribution of gas. As a great number of induction-coils can be placed in the circuit, and as a number of lamps may be placed in the circuit of each coil, it will be seen that the electric light is thus capable of very great subdivision." The second claim of this specification reads: "The use of apparatus for the production of electric light, of induction-coils interposed in a primary circuit for generating separate and independent currents to be used for producing electric light in one or more lamps interposed in such secondary circuits, substantially as herein described." One sheet of drawings, containing three illustrations, accompanies this specification, and these are well worthy of attention. The rights of this patent at present centre in the United Electrical Engineering Company, and its value has been recognised by most of the best-known firms and companies, who have arranged to become licensees and to pay royalties. That the owners of the patent have been moderate in this question of royalties may be known from the fact that litigation has been avoided. The companies and firms who have hitherto not arranged for licenses will, no doubt, do so as soon as they become aware of the facts of the case and that users of transformers have been duly warned of the consequences of infringement. We are glad to hope that this business may be carried through without hint of litigation, as we feel assured there is no desire on the part of the owners of the patent to press unduly upon the profits obtained by business men in the due exercise of the work of the industry. If Gaulard and Gibbs were persistent, and their labours are to be appreciated, what about Paul Jablochkoff, who initiated the idea, and whose name is dropping into oblivion, because his "candle" showed the way and then passed away, whilst his other devices came to nothing in the hands of incapable men. Surely the facts we have mentioned testify once more to the necessity of inventors allying themselves to business men, and not to mountebanks and company promoters. Many good things die stillborn because the men who invent have no idea of business, and the men who undertake the business have only one object, "promotion money." Better remain satisfied with an immediate small return and a prospectively greater one, allied with real business, than be carried away with the glitter of both immediate and prospectively great gains. True business cannot afford to handicap itself with the payment of large sums, other than in perfecting the details of the invention and developing a purchasing *clientèle*.

THE "RICHARDSON" HIGH-SPEED ENGINE.

This engine, as illustrated, has been specially designed for driving dynamos direct or by belt or ropes, and it has been constructed with great care to run at high speeds with safety and economy, and without excessive wear. The crank is made of mild steel, carefully balanced. The cylinder and upright are cast in one piece. The cylinder



is steam jacketted, and is fitted with a liner, which, with the valve face, can be at any time renewed. The piston-rings and valve are of phosphor-bronze, all the bearings are extra long, and are made of either phosphor-bronze or best gunmetal. The crankshaft bearings are fitted in square, with wrought-iron caps, and the glands are specially constructed for lightening whilst running without the risk of jamming on the rods. The governor is of the high-speed class, and is very sensitive, and is also arranged so that it can be adjusted whilst running. An important point with regard to durability is that all the forged parts—bolts, studs, and nuts—are made of mild steel. All parts are made to template, and are interchangeable. The lubricating arrangement is made as perfect as possible, and is adapted for long and continuous running. In mills and other manufactories (also steamships) where the electric light is used, the most practical way of driving dynamos is direct by small high-speed engines, where there is boiler power to spare, as the light can be started before work commences, and can also be kept going at night until all hands are off the premises, and the light can also be kept running all night in case of repairs. These engines are very suitable for this purpose, taking up little room as the engine is fixed on same bedplate as dynamo. These engines will, no doubt, prove useful to electrical engineers where a good, reliable, and economical high-speed engine at a moderate

price is required. Engines of this class can be fitted with automatic expansion arrangement, if required, by the maker, Mr. A. W. Richardson, engineer, Stretford-road, Manchester.

SIEMENS' RECORDING APPARATUS FOR COMPACT MORSE WRITING.

The alphabet formed by the combination of two elementary signs, the "dot" and the "dash," which is used in Morse telegraph instruments of the recording type, is almost universally written in a single longitudinal line on the paper strip.

This method of writing, however, possesses the great disadvantage that the diameter of the writing-discs cannot be made very small, as it would not then be certain to dip into the ink contained in the trough. A disc of comparatively large diameter, although clean in its working, is unsuitable for producing a short and sharp sign on the paper strip, particularly when the strip is moving slowly, as the tangential contact between the writing-disc and the paper produces an unnecessarily long sign with a large disc, and hence the tendency to "tailing" is increased. It is for these reasons that the "dots" of the Morse alphabet can in general practice only be produced as short dashes, so that, in order to prevent misapprehension, the "dashes" require to be made longer than would be necessary if distinct dots could be produced. The writing is thus spread over far more paper than is desirable, causing not only a waste of paper, but making the reading more difficult.

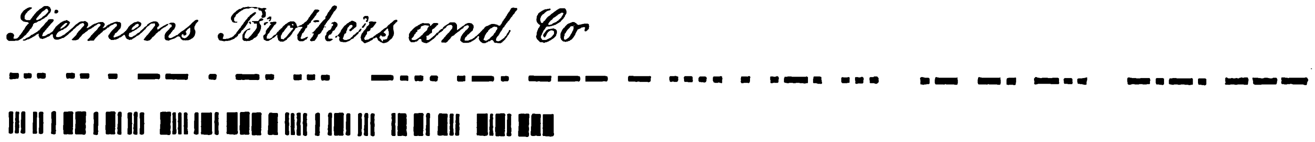


FIG. 1.

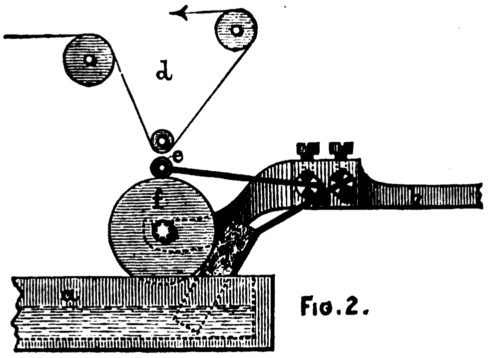


FIG. 2.

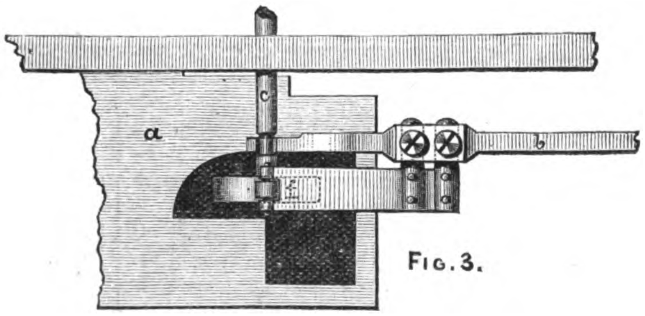


FIG. 3.

Various suggestions have from time to time been made with the object of remedying this defect; but, owing either to complication in the methods of transmission or of reception, none of these proposals have been adopted to any considerable extent.

The "compact writing" has been designed to meet the demand for improvements in the old system of Morse writing. Its elementary signs consist of lines at right angles to the edge of the paper strip and of equal width, but of different length (measured in the direction in which the paper travels), or short or thin line representing a "dot," and a longer or thicker line a "dash."

Fig. 1 illustrates the old and new system of writing, and shows the relative difference in space occupied by them. The length of paper used for the compact writing is about half that used for the old writing, while a more readable message is produced. The amount of paper strip to be stored away for possible future reference thus becomes considerably less—an administrative advantage not to be underrated when the present enormous increase in telegraphic communication is taken into account.

The inking arrangement, by which these compact signs are produced, consists, as shown in Figs. 2 and 3, of a marking-roller, *e*, of a small diameter, and of a width equal to that of the marks to be produced, mounted with its axis at right angles to the edge of the paper strip, and rotated by its frictional contact with the inking-disc, *f*. This inking-disc is carried on a spindle, *c*, resting in a bearing on the end of the armature lever, *b*, and is geared with the clockwork of the instrument by which it is revolved. It is of slightly greater width than the marking-roller, and has a finely-grooved periphery for more effectually taking up the ink. *a* is an ordinary ink-trough, and *g* is a pad of felt, which dips into the ink and presses against the inking-disc. The marking-roller, *e*, and the inking-pad, *g*, are both attached to the armature lever by flexible arms, and the amount of their pressure upon the inking-disc is regulated by small set-screws. *d* is the ordinary train of wheels over which the paper passes.

When the instrument is at work, the end of the armature lever carrying the marking-roller, inking-disc, and inking-pad, is moved upwards by the action of the electro-magnet, the marking-roller being thereby pressed against the paper, making a short or long mark according to the duration of contact. The inking-disc is rotated by the clockwork and, being supplied with ink from the pad, carries it to the marking-roller, which it at the same time causes to revolve. In this manner the marking-roller receives a very even, though ample, supply of ink, and a freshly-inked surface is constantly presented to the paper, by which means, combined with the very small diameter of the roller, short, sharp, and distinct marks are produced.

Experience has shown that any disinclination that may be felt by telegraph operators to change the method of writing the Morse code, is soon removed by the conviction that the new system offers considerable advantages to themselves, and that no difficulty whatever is experienced by the change from the old system to the new.

ON THE DESIGNING OF CONTINUOUS CURRENT DYNAMO MACHINES.*

BY PROF. JAMIESON, M.INST.C.E., F.R.S.E.

(Concluded from page 182).

Suppose we agree to a loss of about 10 per cent. of the total power in the dynamo, or say—

The electrical efficiency of the dynamo = 90 per cent.

$$\therefore 90 \text{ per cent.} : 100 \text{ per cent.} :: 6{,}400\ P_W : x.$$

$$\therefore \text{Total power} = x = 7{,}100\ P_W.$$

Let $$R_a = \frac{R_o}{20} = \frac{1 \cdot 55}{20} = \cdot 077\ \omega.$$

Let $$R_s = R_a \times 1{,}000 = \cdot 077 \times 1{,}000 = 77\ \omega.$$

Let $$R_m = 75\,\%\,R_a = \tfrac{3}{4} \times \cdot 077 = \cdot 058\ \omega.$$

Now, the external current = current in armature and field-magnet main coils less the current in shunt.

* Paper read before the Institution of Engineers and Shipbuilders of Glasgow. The illustrations referred to were given in our last issue.

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Currents.—Or $C_e = C_a - C_s$.

But, $C_s = \frac{E_e}{R_s} = \frac{100\,v}{77\,\omega} = 1 \cdot 3\,a.$

$$\therefore 64\,a = C_a - 1 \cdot 3\,a.$$

$$C_a = 64 + 1 \cdot 3.$$

$$= 65 \cdot 3 \text{ amperes.}$$

Fall of potential in armature $= C_a \cdot R_a = 65 \cdot 3 \times 0 \cdot 77.$

$$= 5 \cdot 02 \text{ volts.}$$

Fall of potential in magnet main coils $= C_m \cdot R_m = 65 \cdot 3 \times \cdot 058.$

$$= 3 \cdot 78 \text{ volts.}$$

Total fall of potential in armature and magnet series coils

$$= C_a \text{ or } C_m (R_a + R_m).$$

$$= 65 \cdot 3\,(\cdot 077 + \cdot 058) = 8 \cdot 8\,v.$$

$$\therefore E_a = 8 \cdot 8 + E_e = 108 \cdot 8 \textit{ volts.}$$

Percentage losses of power.—

In armature $= C_a^2 \cdot R_a = 65 \cdot 3^2 \times \cdot 077.$

$$= 330 \text{ Pw.}$$

$$\therefore 7{,}100 \text{ Pw} : 330 \text{ Pw} :: 100 : x_a.$$

$$x_a = 4 \cdot 63 \text{ per cent.}$$

In shunt coils $= C_s^2 \cdot R_s = 1 \cdot 3_a^2 \times 77\omega.$

$$= 132 \text{ Pw.}$$

$$\therefore 7{,}100 \text{ Pw} : 132 \text{ Pw} :: 100 : x_s.$$

$$x_s = 1 \cdot 86 \text{ per cent.}$$

In main coils $= C_m^2 \cdot R_m = 65 \cdot 3^2 \times \cdot 058.$

$$= 248 \text{ Pw.}$$

$$\therefore 7{,}100 : 248 :: 100 : x_m.$$

$$x_m = 3 \cdot 5 \text{ per cent.}$$

Totalling the different percentage losses we have :

In armature...............	$x_a = 4 \cdot 63$ per cent.
In shunt coils	$x_s = 1 \cdot 86$,,
In main coils	$x_m = 3 \cdot 5$,,
	9·99 %. or say 10%.

Kapp Lines in Armature Core.—Now, before substituting the above data in Kapp's formula, we must agree upon the turns of wire in the armature at the agreed upon 1,000 revolutions per minute. Let there be 36 commutator bars or 36 sections of wire in armature, which has been found sufficient to give a current of practically uniform E.M.F. The number of turns of wire in each section of the armature depends upon whether we use double or single winding, and upon the current and the resistance of the armature wire. As we shall see further on, from our trial drawing and calculations, we can get in six turns of wire to each section.

$$\therefore T_{aw} = 36 \times 6 = 216 \text{ turns of armature wire.}$$

Let $N_{ar} = 1{,}000$ revolutions per minute.

Now $E_a = \mathbf{K}_L \times T_{aw} \times N_{ar} \times 10^{-6}.$

$$\therefore \mathbf{K}_{La} = \frac{E_a}{T_{aw} \times N_{ar} \times 10^{-6}}.$$

$$= \frac{108 \cdot 8\,v}{216 \times 1{,}000 \times 10^{-6}} = 503 \cdot 7$$

say = 500 Kapp lines in *armature core.*

In order to obtain a certain number of Kapp lines or magnetic induction in an armature core, it is necessary to give a greater magnetic intensity to the field-magnet core or cores, owing to the unavoidable leakage of magnetic lines which do not pass through the armature core.

Dimensions of Magnet Core.—In ordinary practice it is usual to assume that only about 80 per cent. of the field-magnet lines pass through the armature core.

Therefore, the Kapp lines in *field-magnet* are

80 per cent. : 100 per cent. :: 500 : $x = 625$.

We must now ascertain the dimensions of the field-magnet core to carry these 625 Kapp lines. Suppose we consider the case of field-magnets to be cast iron throughout (poles and core).

A safe working density is 9 Kapp lines per square inch.

$$\therefore \mathbf{S}_m = \frac{625}{9} = 69 \cdot 4 \text{ square inches.}$$

$$= 9 \cdot 4 \text{ inches diameter (if round).}$$

In practice it is found that a dynamo magnet bobbin should be in length about $1\frac{1}{4}$ times its diameter to give the necessary space for winding or ampere-turns.

$$\therefore 9 \cdot 4 \times 1 \cdot 25 = 11 \cdot 75 \text{ inches long.}$$

Dimensions of Armature Core.—It has been found advisable, in designing the dimensions of the armature core of a dynamo having a field-magnet of the form we are now considering, to make the diameter of its core slightly larger, and its length slightly less, than the diameter of the field-magnet core.

Therefore, calling the diameter of the Gramme armature core 10in., its length 9in., and allowing a density of 20 Kapp lines per square inch of core section, since it is made of the best permeable wrought iron, we have

$$\frac{500}{20} = 25 \text{ square inches total cross-section of armature.}$$

$$\therefore \mathbf{S}_a = 25 \text{ square inches.}$$

Allowing 20 per cent. of total space for insulation between *laminated plates* in armature core, we have

80 per cent. : 100 per cent. :: 25 : $x = 31 \cdot 5$ square inches.

$$\therefore \frac{31 \cdot 5}{2} = 15 \cdot 75 \text{ square inches in each half.}$$

$$\therefore \frac{15 \cdot 75}{9''} = 1 \cdot 75\text{in.} = \text{radial depth of core.}$$

Magnetic Resistance of Field-Magnet.—Now, drawing armature and field-magnets to scale (as per Fig. 4) and allowing $2\frac{1}{4}$in. for depth of winding on field-magnet bobbin and clearance for armature, we find the mean length of field-magnet core, $\mathbf{L}_m = 44$in., and remembering that in a formula for the magnetic resistance of this part of the circuit we have to use a coefficient of 3 instead of 2, seeing that the core is of cast iron, we have

$$\mathbf{R}_m = 3\,\frac{\mathbf{L}_m}{\mathbf{S}_m}.$$

$$= 3\,\frac{44}{6 \cdot 94} = 1 \cdot 9.$$

Magnetic Resistance of Air Space.—With *two* layers of insulated conductors having a cross section (▭) of ·08in. deep, by ·2in. broad (including covering), we find the total depth of air space on one side between pole-pieces and armature core (allowing ·14in. mechanical clearance), equal ·3 of an inch.

Consequently, $2\,\mathbf{L}_{as} = 2 \times \cdot 3 = \cdot 6$in.

The bore of pole-pieces will be = diameter of armature core + $2\,\mathbf{L}_{as}$

= 10in. + ·6in. = 10·6in.

It is good practice to allow the corners of pole-pieces to form an angle of 30deg. with centre of armature. The angle embraced by each pole-piece will therefore be 180deg. – 30deg. = 150deg., which gives us a circumferential length of, say, 14in. for each pole. And since our armature core is 9in. long, and it is unusual to make the pole-pieces broader than this length, we have

$$\mathbf{S}_{as} = 14\text{in.} \times 9\text{in.} = 126 \text{ square inches.}$$

Hence— $\mathbf{R}_{as} = 1{,}800\,\frac{2\,\mathbf{L}_{as}}{\mathbf{S}_{as}},$

$$= 1{,}800\,\frac{2 \times \cdot 3}{126} = 8 \cdot 5.$$

Magnetic Resistance of Armature.—Referring to scale or full-size section, we find by measurement that $\mathbf{L}_a = 15$in. We have already determined $\mathbf{S}_a$ to be 25 square inches.

Consequently— $\mathbf{R}_a = \frac{\mathbf{L}_a}{\mathbf{S}_a},$

$$= \frac{15}{25} = \cdot 6.$$

$$\therefore \mathbf{R}_m + \mathbf{R}_{as} + \mathbf{R}_a = 1 \cdot 9 + 8 \cdot 5 + \cdot 6$$

= 11 Kapp units of magnetic resistance.

Ampere-Turns.—From formula for *cast* iron, under heading VIII.

$$\mathbf{K}_L = \frac{A \times T_{fw}}{\mathbf{R}_m + \mathbf{R}_{as} + \mathbf{R}_a} = 625 \text{ (gross Kapp lines)}$$

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Therefore $A \times T_{mw} = K_L (R_m + R_{as} + R_a)$,
$= 625 \times 11$,
$= 6,875$ total ampere-turns in shunt and main field magnet coils.

Proportioning of Ampere-Turns between Shunt and Main Coils.—The total ampere-turns have now to be divided in proper proportion between the series coils and the shunt-coils of the field-magnet windings.

In order to do this, so as to give the desired form of characteristic curve, we must have recourse to actual experiment. The following method is carried out by Messrs. M'Whirter, Ferguson, and Co., Faraday Works, Govan :

1. A workshop bobbin or experimental coil, with a known number of turns of wire, is kept for every size of dynamo machine made. This bobbin is put on to the magnet core in circuit with an ampere-meter, and is separately excited by another dynamo or storage cells. The dynamo to be wound is run at the normal speed with the external circuit, R_e, equal to that of shunt—viz., 77 ω—and with the voltmeter placed between the terminals. The exciting current through the experimental bobbin is now gradually increased until the required number of volts is observed on the voltmeter—*e.g.*, suppose the experimental bobbin to have 500 turns, and the ampere-meter reads 8·25 amperes, when the normal voltage of 100 volts is reached, then the ampere-turns of shunt wire

$$A \times T_{sw} = 500 \times 8{\cdot}25 = 4,125 \text{ ampere-turns.}$$

2. Connect up the armature of the dynamo being constructed to a resistance equal to the joint resistance of the shunt, and the normal lamp circuit through an ampere-meter, and run the dynamo at the normal speed. Now increase the exciting current in the experimental bobbin until the normal voltage of 100 volts and normal armature current of 65·3 amperes are both obtained. At the same time observe the exciting current.

But the total required ampere-turns = 6,875, and from experiment (1) we found that 4,125 ampere-turns produced the requisite E.M.F.

∴ 6,875 − 4,125 = 2,750 ampere-turns left for series-coils.

3. The normal current at full load required to pass through the series-coil was found to be 65·3 amperes.

Consequently the number of turns required in the series-coils

$$= \frac{2,750}{65{\cdot}3} = 42 \text{ (about).}$$

4. From experiment (1), we found that 4,125 ampere-turns gave us the required excitation to produce the normal E.M.F., and from our former calculation we found that the current in shunt,

$$C_s = 1{\cdot}3 \text{ amperes.}$$

$$\therefore \frac{4,125}{1{\cdot}3} = 3,173 \text{ turns.}$$

But the series-coils are also carrying the 1·3 amperes required for the shunt when dynamo free.

∴ 3,173 − (42 turns × 1·3 *a*) = 3,173 − 54 = 3,119 turns on shunt-coils.

5. All we now have to do is to so proportion the size of our series and shunt coil conductors that they shall carry the necessary currents required in each case at the rate of not exceeding 1,000 amperes per square inch. For armatures this may be and is in practice increased to even 3,000 amperes per square inch without undue overheating, owing to the cooling effect of the air carrying off the heat generated in the revolving armature. Mere radiation only acts on the field-magnet coils, therefore the sectional area is of necessity much greater.

Example II.—Now take the case of a Rankin-Kennedy short shunt compound dynamo of the form shown by Fig. 1. The particular dynamo in question was tested by the writer after completion, with the following results :

Resistance of armature, warm,	R_a	= ·04 ohm.
Resistance of magnet shunt, warm,	R_s	= 20 ohms.
Resistance of magnet main coil, warm,	R_m	= ·03 ohm.
Current in working circuit,	C_e	= 108·5 amperes
Current in shunt-magnet coils,	C_s	= 5 amperes.
Difference of potential at dynamo terminals,	E_e	= 100 volts.
Difference of potential at brushes,	E_b	= 103 volts.
E.M.F. generated in armature,	E_a	= 108 volts.
Turns of armature wire,	T_{aw}	= 180.
Number of armature revolutions per minute,	N_{ar}	= 620.

Electrical Efficiencies.

External electrical power, or "output," available for electric lighting, etc.,

$= C_e \times E_e = 108{\cdot}5_a \times 100_v = 10,850$ watts = 88·7%

Power absorbed by armature,

$= C_a^2 \times R_a = (113{\cdot}5)_a^2 \times {\cdot}04\omega =$ 515 watts = 4·2%

Power absorbed by shunt magnet-coils,

$= C_s \times E_s = 5_a \times 103_v =$ 515 watts = 4·2%

Power absorbed by main magnet-coils,

$= C_m^2 \times R_m = (108{\cdot}5)_a^2 \times {\cdot}03\omega =$ 353 watts = 2·9%

Total electrical power,

$(C_e \times E_e) + (C_a^2 \times R_a) + (C_s \times E_s) + (C_m^2 \times R_m) = 12,233$ watts.

The only difference between this dynamo and our last example being that the magnet core was made of the best hammered scrap iron instead of cast iron, and consequently the permeability is greater. The constants to be used in the formula are therefore less, and we have to substitute 2 for 3, and 1,500 for 1,800 as found by experiment.

From the measured dimensions of the dynamo we found :

$L_m = 38$ inches.	$S_m = 98$ square inches.
$L_{as} = 0{\cdot}45$ "	$S_{as} = 195$ "
$L_a = 15$ "	$S_a = 46$ "

$$\therefore R_m = 2\frac{L_m}{S_m} = 2\frac{38}{98} = {\cdot}76$$

$$R_{as} = 1,500\frac{2L_{as}}{S_{as}} = 1,500\frac{2 \times {\cdot}45}{195} = 6{\cdot}9$$

$$R_a = \frac{L_a}{S_a} = \frac{15}{46} = {\cdot}33$$

Total magnetic resistance = 7·99

Now by substituting in our former formula the actual values obtained for the E.M.F. in the armature, turns of armature wire, and revolutions per minute, we get the magnetic flux in Kapp lines flowing through the armature. Or,

$$K_{La} = \frac{E_a}{T_{aw} \times N_{ar} \times 10^{-6}}$$

$$= \frac{108}{180 \times 620 \times 10^{-}}$$

= 968 *lines of magnetisation through armature, or at the rate of* 21 *Kapp lines per square inch.*

But in dynamos of this class it has been found that the number of magnetic lines passing through the armature are only 80 per cent. of the total magnetisation in the field-magnets. Consequently,

$$80\% : 100\% :: 968 : x$$

∴ $x = 1,210$ *Kapp lines through the magnet cores, or at the rate of* 12·3 *Kapp lines per square inch.*

From our former formula,

$$K_L = \frac{A \times T_{mw}}{R_m + R_{as} + R_a}$$

$$1,210 = \frac{A \times T_{mw}}{7{\cdot}99}$$

= 9,668 ampere-turns on the field-magnets.

The actual ampere-turns were 9,800, or the calculation is only about 1 per cent. less than the *actual* amount required to satisfy the requirements of the installation.

Example III.—Take the case of a Faraday compound dynamo, also tested by the writer, supplied by Messrs. M'Whirter, Ferguson and Co., Govan, to the Blair Lodge School. Where (see Fig. 3)

R_a = ·0315 ω	E_e = 100 v.
R_s = 31·0 ω	E_a = 107·6 v.
R_m = 0·012 ω	E_b = 102 v.
C_e = 130·0 *a*	T_{aw} = 240 (48 commutator bars)
C_s = 3·55*a*	N_{ar} = 800

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This dynamo being of the double horseshoe magnet type, and the cores being of the best Swedish iron, with large cast-iron yokes, we use a constant two for wrought-iron cores, and 1,440 for specific resistance of copper and air space due to wrought cores and pole-pieces.

From the actual dimensions of the dynamo we found:

$\mathbf{L}_m = 32{\cdot}0$in. $\quad \mathbf{S}_m = 33$ square in. (only 1 magnet core).
$\mathbf{L}_{as} = 0{\cdot}5$,, $\quad \mathbf{S}_{as} = 54$,, ($\frac{1}{2}$ hair-space surface).
$\mathbf{L}_a = 12{\cdot}0$,, $\quad \mathbf{S}_a = 15{\cdot}6$,, ($\frac{1}{2}$ section of armature).

$$\therefore \mathbf{R}_m = 2\frac{\mathbf{L}_m}{\mathbf{S}_m} = 2\frac{32}{33} = 1{\cdot}94$$

$$\mathbf{R}_{as} = 1{,}440\frac{2\mathbf{L}_{as}}{\mathbf{S}_{as}} = 1{,}440\frac{2 \times {\cdot}5}{54} = 26{\cdot}6$$

$$\mathbf{R}_a = {}^*2\frac{\mathbf{L}_a}{\mathbf{S}_a} = 2\frac{12}{15{\cdot}6} = 1{\cdot}54$$

Magnetic resistance of half-dynamo field = 30·08

Now,

$$\mathbf{K}_{La} = \frac{\mathrm{E}_a}{\mathrm{T}_{aw} \times \mathbf{N}_{ar} \times 10^{-6}}$$

$$= \frac{107{\cdot}6}{240 \times 800 \times 10^{-6}}$$

= 530 *lines of magnetisation through armature, or at the rate of*

$\frac{530}{15{\cdot}6 \times 2} = 17$ *Kapp lines per square inch of armature section.*

Allowing, as before, that only 80 per cent. of the total magnetisation passes through the armature, we have

$$80\% : 100\% :: 530 : x.$$

$x = 662$ Kapp lines through both the magnet cores, or 331 lines through each half, which is at the rate of 10 Kapp lines per square inch of magnet core section.

$$\therefore \mathbf{K}_L = \frac{\mathrm{A} \times \mathrm{T}_{mw}}{\mathbf{R}_m + \mathbf{R}_{as} + \mathbf{R}_a}$$

$$\text{Or } \mathrm{A} \times \mathrm{T}_{mw} = \mathbf{K}_L\,(\mathbf{R}_m + \mathbf{R}_{as} + \mathbf{R}_a)$$

$$\therefore \mathrm{A} \times \mathrm{T}_{mw} = 331 \times 2 \times 30{\cdot}08 = 19{,}913.$$

The actual ampere-turns were 20,850, and the dynamo having a rising characteristic of 3 per cent., the calculation is only about 1·7 per cent. less than actually found by experiment.

SOME ELECTRIC LIGHTING CENTRAL STATIONS IN EUROPE AND THEIR LESSONS.†

BY PROF. GEORGE FORBES, F.R.SS. (L. AND E.), MEMBER.

PART I.

Before commencing the subject of this paper, I think it may be well if I give you some idea of the reasons why I have brought the subject to your notice. You are aware that great strides are about to be made at the present time in electric lighting in this country, specially by means of the Gaulard and Gibbs system with the converters put in parallel. To complete the practical details of such a system involves a large amount of experiment, and whether low-pressure or high-pressure work is in question, I have frequently maintained that a great deal of experience has still to be bought and time to be wasted. It has appeared to me that we can only hope to ensure the best success of electric lighting schemes now in hand if we bury our pride a little, and try to obtain the experience of foreign countries without paying for it or wasting time over it, as they have done. Some irresponsible persons have considered that I am much to blame for thus advocating the discussion, and consequent approval or disapproval, of systems which have been developed in foreign countries. I do not say that we are not even now capable of doing much better work than these countries, as we have done with steam, and I am certain that we shall do so in the course of time; but I do say that we are wanting in the experience, and I see all over the country work being done where the rules of experience have often been set at defiance; and my object in introducing this subject is chiefly for the second part of the title of the paper—namely, a discussion of the lessons which can be derived from a study of the work which has been done abroad. The object of this paper, then, is to raise a discussion on the details of central station lighting and electrical distribution, and to enter a protest against defective systems, which, without some such discussion, I feel sure will be as plentiful in the near future with us as they have been up to the present time.

Of course I am aware that many of my hearers have appreciated these points, and have, like me, tried to learn from those who have had most experience; and I know that they will pardon me for drawing attention to work that they have already examined, since they know as well as I do the need we have for such discussion.

I believe that my object can be best attained by proceeding, first, to describe the principal central stations in Europe which I have lately visited, pointing out specially the features in which they differ from the practice in this country so far as hitherto developed; and then to discuss the details, with a view of deriving the most profitable lessons from them as to what to adopt and what to avoid. I will deal only with what I believe to be the three most important central stations in Europe—namely, Berlin, Rome, and Milan. I have already partially dealt with America elsewhere.*

Berlin is supplied on the low-tension direct-current system, as originally developed by Edison, except the arc lights, which are on a high-pressure direct-current circuit.

Rome is supplied altogether, both for arcs and incandescent, on the Gaulard and Gibbs system, with converters arranged in parallel.

Milan is worked by Thomson-Houston apparatus for arcs, and by both low-pressure currents and high-pressure alternating currents for incandescent lamps.

At all the European stations which I have visited I received the same cordial welcome which I have always had in America, and the same desire that I should thoroughly inspect every part of the works. The stations have literally been placed at my disposal to watch the action of the machinery, and to see what attention is required for its management. I have been allowed to interchange dynamos at will, and generally to learn all that was possible. I must especially record my thanks to Signor Pouchain, Prof. Mengarini, Signor Trenza, Prof. Colombo, Mr. Lieb, Herr Rathenau, and Herr Datterer, for the willingness with which they imparted to me so much information in the details of their working, and to Mr. Zipernowski and Messrs. Ganz and Co. for much valuable information.

Berlin.

The Berlin mains are at present, I believe, supplying a larger number of lights than any other connected system of mains in Europe. They supply 36,000 lamps of 16 c.p., and 144 arc lamps of 15 amperes. The conductors are all laid underground. A map is shown giving the position of mains already laid down and those in progress of construction. There are three central stations at work, and two more of improved type are in process of construction.

The existing stations are: 1. Markgrafen Strasse. 2. Meuer Strasse. 3. Friedrich Strasse.

Those about to be added are: 4. Spandauer Strasse. 5. Schiffbauer Damm.

The first is the most important; the third is quite unimportant. Here the boilers are by Steinmiller, and anthracite coal is used to prevent nuisance from smoke. The foundations are of concrete, in iron boxes, built up with brickwork and cement. There are six engines, of 160 h.p. each, each driving old-fashioned Edison six-legged dynamos. There are also four engines, of 400 h.p. each, each driving a new type of dynamo direct at 80 revolutions per minute. These are compound tandem Corliss condensing-engines, by Van den Kirchove, of Ghent, who is one of the few foreign makers of engines who can compete with this country. The attached dynamos are by Siemens and Halske. The Electric Company of Berlin are also making a machine somewhat similar. A diagram is shown of this dynamo and of the engine combined, the height of which is 23ft. These continuous-current dynamos have never been built in this country, and are worthy of some notice. They may be described as multipolar Gramme machines, the poles being radial, and the ring armature external to the poles.

There are ten poles on each machine. The armature is 3 metres in diameter; the commutator is 1½ metres in diameter. There are 10 brush-holders. Each pair of poles, and the corresponding part of the armature, with the corresponding pair of brush-holders, constitute a section which is virtually one machine. All these sections are joined in parallel. The field-magnets are not seen in the drawing, being inside the armature. Two handles are provided, one of which adjusts all the brushes at the same time; the other puts them on all together. Each brush-holder carries four brushes. Another drawing is shown of a similar dynamo being made by the Berliner Elektricitäts-Werke, in which the radial poles are external to the armature. I believe that this type of multipolar machine is a good design where the object is to get a large output with a slow speed. I hold working drawings in my hand of a similar design prepared by myself in 1881, but it was never executed. The number of bars of the commutator and the number of parts generally make it expensive to construct.

* 2 is here on account of the double field, or the magnetic lines or circuit entering from each side.

† Paper read before the Institution of Electrical Engineers, Feb. 28.

* British Association, 1888.

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At this station the boilers are fed automatically by means of a hydraulic accumulator. The water for condensing is drawn from 15 artesian wells which have been sunk for this purpose. Steam is used at a pressure of 115lb., and it is claimed that 15·5lb. of steam only are required per electrical horse-power. This is probably the most economical production of electricity for central station work in the world, and the engines and dynamos, though expensive, must certainly have a very low depreciation. The maximum work which this station can do is to generate a current for 26,000 lamps of 16 c.p. It is found that the maximum number of lamps in use at any one time is about 66 per cent. of the total number of lamps.

The thing which strikes one most in this station is the enormous mass of copper. The conductors inside this station consist of eight strips of copper, 6in. wide and $\frac{1}{3}$in. thick. These are laid into the room for cable terminals. These strips, before entering this room, are interrupted by a gap, and a junction is made by punching seven similar strips, about 18in. long, between the strips and the interrupted ends, the seven strips being placed between. Thus, in case of any serious accident, the whole of the mains can, by one turn of a screw, be disconnected from the dynamos, the interlapping pieces all dropping out. The only exception is in the case of theatres, where, to prevent panic, a separate connection is made with the dynamos. In the cable terminal room the positive and negative mains run horizontally, and vertical rods come down to the different cables. There are 84 of these cables, forming 42 pairs of feeders supplying the network of mains with current on the two-wire system. These cables are generally of large size, being frequently 3in. in diameter complete. They consist of stranded cables covered with jute prepared with bituminous compound, enclosed in lead, then covered with tape and preservative compound, and finally armour-plated with two crossed spirals of iron ribbon. The system of feeders and mains is one of the features to which I wish to direct the special attention of English engineers, since the principle has been adopted of trying to produce as small a variation of pressure in the mains as possible. This is accomplished by having a large number of converters. The cost of the underground cables has hitherto amounted to about £90,000, half of this being spent in mains and half in feeders. The greatest variation of pressure allowed in the mains is 1½ per cent. The loss of pressure in the feeders during periods of maximum supply is 15 volts.

The next point which I wish to draw special attention to in connection with the Berlin central station work is the type of cable which I have now described. This cable succeeded very well for three years, but lately they have been giving way very generally. The lead gets eaten into and water percolates to the copper, which is then destroyed. At first it was supposed that the deterioration came from the cable being pierced by the borers used by the gas people, but it was found that the same fault is produced even in iron pipes which have remained uninjured. It is supposed that the deterioration of the lead may be due in some way to its forming a galvanic element with the iron sheathing. Whatever the cause may be, the fact seems to be established that such cable will not stand underground electric light work for more than about three years. These cables generally run under the footways without any casing, and are connected by circular junction-boxes to the houses, powerful clamps and no soldering being used for the contacts. All the dynamos feed direct on to the mains in parallel. One feeder alone, serving the mains close to the station, has a resistance in circuit in the station to equalise its loss of pressure to the others.

A few detached facts strike me as being worth noting. Each 16-c.p. lamp uses 50 to 55 watts. The charges for electric supply are 6s. per lamp per annum, and 9·6d. per Board of Trade unit. The Aron meter is universally employed. The price of gas in Berlin is 4s. 10d. per 1,000 cubic feet. The distances from central stations to lamps extend to 1,000 or 1,200 yards; 100 kilometres of cable have been laid on the two-wire system. Each of the large machines can supply 3,000 to 3,500 lamps of 16 c.p. The largest cable is 1½ square inches of copper in section.

I spent a long time in this station, and had machines taken off and put on—an operation which occupied two or three minutes. I took careful note of the amount of skilled attention which was required, and saw that it was considerable. A man of high training, accustomed to the use of scientific instruments, is always in attendance and looking after the amperes and volts from the different machines and pilot wires, and recording the measurements. It struck me that the working of this station was thoroughly German—certainly not American—but it was most methodical and very effective. One of the most interesting parts of this central station is the switchboard, with the special means for introducing a fresh dynamo in parallel, or cutting it out. This also is a point to which sufficient attention has not generally been given in England. In all foreign stations that I have ever seen, when a current of over 100 amperes is switched in or out, it is found necessary to make use of an auxiliary load in the form of resistances, a bank of lamps being generally employed as being the cheapest resistance available. When a new dynamo is going to be introduced in parallel, it is first worked on an artificial load, and the exciting current regulated until the volts and amperes agree with those of the other dynamos with which it is to be put in parallel. As soon as this equilibrium is attained, the mains are switched into connection with the new dynamo and its load. After that the load is taken off. This prevents the possibility of the dynamo thus introduced being caused to run as a motor in the wrong direction by the current from the other dynamos, and prevents too violent a sparking at its brushes. The switchboard at this central station for the four large dynamos, with the accompanying artificial load or resistance, and with its ammeters and voltmeters, is very perfect. Facing the operator, the switchboard is in four sections for the four dynamos. Each dynamo has three massive double-pole switches—one for the dynamo, one for the artificial resistance, and one for the mains. Plugs can be inserted for varying the resistance on the artificial load. The ammeter is placed above these switches for each machine, and a voltmeter can be attached to any one of them, as required. A photograph of this switchboard is reproduced.

The second station is in the Mauer Strasse. This station helps to feed the mains for incandescent lamps. It also supplies arc lights arranged in 12 circuits all arranged in parallel, each circuit having 12 arc lamps of 14 to 15 amperes. Here three Siemens machines of the old type are driven by a countershaft. Three Siemens and Halske new-type multipolar machines are also at work, and four Edison machines and six multipolar machines of low tension. Eleven thousand lamps of 16 c.p. can be supplied besides the arcs. Sixty-eight feeders, or 34 pairs, start from this station.

The Friedrich Strasse station is small, and was the commencement of the present system. Here four six-legged old-type Edison machines, each of 75 h.p., are driven by Armington-Sims engines, and feed the general system of mains. Fifty-two men are employed on the three stations in eight-hour shifts. The Berliner Elektricitäts-Werke paid last year a dividend of 5 per cent.; the Algemeine Elektricitäte Gesellschaft, which does the central station work, paid last year 7½ per cent. In special districts 800 or 900 lamp-hours per annum are used; in residences only 400 to 500 lamp-hours per annum. Load diagrams showing the current used at different hours of the day in each month, and the proportionate cost from different causes, fixed and variable, have already been published, but are here reproduced.

Milan.

The central station in Milan is not of the highest importance, so far as we can learn anything from it, except on one important point. The principal streets throughout the whole town are lighted by Thomson-Houston arc lights to the number of 350. This lighting gives us some idea of the manner in which this metropolis will soon be lighted, and anyone who sees it and realises that this clear, white, brilliant illumination may be made to brighten our wider thoroughfares, and to penetrate our darkest slums, will realise that when London is as far advanced in adapting these possibilities of civilisation as Milan is, we shall lead healthier, happier, and purer lives, and our streets will be less notorious throughout the world as the hotbeds of immorality and midnight assassination.

I will briefly refer to the points which struck me as being most worthy of notice. The station has 14,000 incandescent lamps of 16 c.p. The maximum load is 60 per cent. of the number of lights installed. At this station it has been found quite practicable to use Siemens ratchet arc lamps of only 4½ amperes, the upper carbon being 12mm. diameter and 200mm. long, the lower one 7mm. diameter and 200mm. long, lasting 7½ to 8 hours. For long duration, larger carbons are used up to 15 hours. This is the first station where I have seen an arc lamp of so low a current in use. A certain resistance is put in series with the lamp, and two lamps are put in series on the mains feeding the Edison lamps.

The La Scala Theatre has 2,800 glow lamps of 16 candles and 30 arcs on the same mains. Edison meters are used, and have given great satisfaction. The price is fixed on a sliding scale, varying from 7d. to 1s. per Board of Trade unit. Gas now costs about 6s. 9d. the 1,000ft. Before the electric light was introduced it was 10s. 6d. the 1,000ft.

Two of the theatres are supplied by two Zipernowski machines, each of 40 amperes and 2,000 volts. For these circuits Siemens concentric cables, of which a specimen is exhibited here, are used, the section being 28 square millimetres. Four Thomson-Houston machines are supplying 35 arc lights each, and four more are supplying 30. Half of these are single and half double carbon lamps, the single ones being put out at midnight. I should mention that the coal used costs 27s. 6d. per ton, but labour is cheap.

Ten Babcock and Wilcox boilers supply the steam. The engines are all non-condensing. The low-pressure system is a two-wire system. Twenty-eight cables, or fourteen pair of feeders, supply current to the mains. No pilot wires are used, but a man reads the ampere-meter and sets the volts by a table. There are ten Edison machines of what is known as the Jumbo

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type feeding mains on the two-wire system. They were originally supplied each with a separate regulator for adjusting the exciting current, but connecting gear has now been introduced, which works them all simultaneously. A fan is provided for driving air through holes in the poles of the field-magnets. The whole of the low-tension system is antiquated, and we have little to learn from it except what to avoid. I found the arrangements for switching dynamos in and out worked very well. An artificial load of lamps is used at one part of the room, a main going thence past each dynamo. Thus two men are required to put in a new dynamo. It is first put on to the lamps, the machine being excited to the same extent as the other ones. The load of lamps is changed until the volts are the same as on the working circuit. A signal is then given, and the dynamo with its load is switched on to the working mains. The load of lamps is then removed. This is simpler that at Berlin, owing to the fact that the exciting current is known beforehand, but less simple owing to the dynamo switches being distant from the lamps and voltmeters. Ten machines work thus in parallel without trouble, which is a very good performance.

At Milan, the average cost for wiring houses is only £1 per lamp. Wages are one-fifth of the total working expenses, coal is one-half, lamp renewals (undertaken by the company) is 7 per cent. The capital is £120,000, of which £24,000 has been spent in mains. The company has paid a dividend for several years. It is steadily increasing, and was 4 per cent. last year. There is a large reserve fund.

Plans are exhibited, one showing the positions of the arc lamps, and also the alternate-current circuits, and the other showing the low-pressure mains and feeders, with the junction boxes and distributing boxes. Another drawing shows the station in section, with the engines and dynamos on the ground floor, and the boilers on the first floor. Another shows the plan of the engine and dynamo room.

(To be continued.)

LEGAL INTELLIGENCE.

IN RE GAULARD AND GIBBS' PATENT.

This was an appeal, before Lords Justices Cotton, Lindley, and Lopes, by Messrs. Gaulard and Gibbs and the National Company for the Distribution of Electricity by Secondary Generators, Limited, against the revocation by Mr. Justice Kekewich, on the application of Sebastian Ziani de Ferranti, of letters patent (No. 4,362 of 1882) which were granted to Gaulard and Gibbs in respect of "a new system of distributing electricity for the production of light and power." Shortly stated, the appellants claim to have been the first to solve, by their patent of 1882, the problem which had for some years greatly exercised the minds of electricians and men of science, of devising a system of electric distribution that would enable a single dynamo machine to supply electricity at a high tension and feed a succession of lamps at local stations, which might be turned off and on independently of one another, by a long main wire, so small as to avoid the great expense of a wire of large diameter. At the same time, the electricity is made practically serviceable, and the danger that would arise if electricity of a high tension were used in houses and buildings is obviated in practice, by constructing the local secondary generators, or induction-coils, so that the induced electricity shall be of a sufficiently low tension. It was admitted that the three elements—an alternating dynamo machine for supplying an electric current at high tension, a small conducting-wire, and induction coils, or secondary generators—were not new in themselves; but it was claimed that the appellants had been the first so to combine and select these elements as successfully to overcome the difficulties of distributing electric light over a large area from a central station —*e.g.*, at the different stations of the Metropolitan Railway (a circuit of some 15 miles) from the Edgware-road as a central station of installation. The respondent, Sebastian Ziani de Ferranti, was an electrician, and in December, 1885, he had obtained provisional protection (No. 15,141, 1885) for an invention in respect of "improvements in electrical conductors," and since filed a complete specification. The sale of secondary generators constructed according to his invention having been interfered with by the appellants as an infringement of their patent, Ferranti in December, 1886, after obtaining the fiat of the Attorney-General under section 19 of the Patents, etc., Act, 1883, presented a petition for revocation of Gaulard and Gibbs's patent of 1882. The grounds (as stated in the particulars of objection) in support of this petition were that the alleged invention was not novel, but consisted solely of a suggestion to use on a large scale the ordinary and well-known mode of deriving electrical action by induction, by means of an induction-coil, from a conductor carrying a varying current, the means employed, and their practical use for such purposes being well known; and, accordingly, that the alleged invention (of Gaulard and Gibbs) made no useful addition to the stock of knowledge existing at the time, and was not a fit subject matter for letters patent. The validity of the patent was also contested on the ground that the claim was for a principle only; that the specification was insufficient, misleading, and erroneous; and also that the invention claimed by the complete specification differed materially from that described in the provisional specification. Prior publication by antecedent specifications and prior user were also alleged in the particulars of objection. Subsequently to the presentation of Ferranti's petition liberty was obtained by Gaulard and Gibbs from Mr. Justice Kekewich, on the terms of paying all costs, to apply at the Patent Office for leave to amend their complete specification by striking out certain parts. The specification as it originally stood, it was argued, seemed to assert that any number of induced currents could be produced by the high-tension current in the main wire without loss of electric energy in the main current—a claim which the petitioner's counsel said amounted to an assertion that the inventors had discovered perpetual motion. By the complete specification as amended the system of Gaulard and Gibbs was stated to consist "of the employment of an alternating current produced by an electro-dynamo machine, and determining by its passage through a number of electrical generators of special construction the formation of induced currents, of which the quality and the value depend only on the construction of the secondary coils of the said electrical generators. The currents generated under these conditions are utilised either by lamps to produce light or by magneto machines to produce motive-power." And the claim as amended was for—"1. The employment of an alternating current of high tension for the generation on a number of secondary generators of induced currents, individually utilised either for the production of light or motive-power. 2. The system of electric distribution such as is laid down in the foregoing statement." The petition was heard before Mr. Justice Kekewich in the course of last year, and on July 9 his lordship gave judgment in favour of the petitioner on the ground that the patentees, Messrs. Gaulard and Gibbs, had not in their specification, as amended by way of disclaimer, sufficiently explained their invention and how it was to be performed. On the question of anticipation, having decided against the patentees, he did not consider himself called upon to examine the evidence and reconsider the arguments as deliberately as he would if he had rested his judgment on that ground; but he expressed the opinion that subject to such revision the patentees had not published to the world, so as to add to the stock of common knowledge, anything which was not already disclosed by some one or more of the earlier specifications. If he could hold the patent to be good on other grounds, he certainly should not hold it to be bad on the point of utility; but being of opinion that what Messrs. Gaulard and Gibbs described in their amended specification as their invention, and for which they claimed a monopoly, was not the proper subject matter of a patent, and that, therefore, the patent granted to them ought to be revoked, his lordship made an order for revocation, with costs to be paid by Messrs. Gaulard and Gibbs.

From this decision the present appeal was brought.

Mr. Aston, Q.C., and Mr. J. C. Graham appeared in support of the appeal; Sir Horace Davey, Q.C., Mr. Moulton, Q.C., and Mr. L. E. Pyke for the respondent Ferranti.

Lord Justice Lindley delivered the judgment of the Court. After stating the nature of the proceedings, which were by way of petition to revoke letters patent, a petition having by recent legislation been substituted for the old action of *scire facias*, his lordship said: The objections taken to the present patent are as follows—viz., (1) that having regard to the previous state of knowledge, the patentee's invention was not one for which a patent could be obtained; (2) that the complete specification is not for the same invention as that described in the provisional specification; (3) that the nature of the invention is not particularly described and ascertained by the complete specification; (4) that the complete specification has been so enlarged by amendment as to destroy the patent; (5) that the patented invention is not new. This last objection is so connected with the first as really to merge into it. In order to deal with these objections, the first thing to be done is to discover what the invention really is according to the patentee's own description of it. For that purpose, the complete specification in its original shape ought to be studied in the first instance rather than the provisional specification, for the former document particularly describes and ascertains the invention, while the latter only states its general nature. If the provisional specification is studied in the first instance, a general, but loose and inaccurate, idea of the real invention is likely to be obtained, and an incorrect conception may be thus formed, and if formed will probably lead to error. Turning, then, to the complete specification as it stood before it was amended, let us see what the invention really is. The patentees claim to have discovered a new system of distributing electricity for the production of light and power. The system consists of a combination of the following particulars—viz., (1) an alternating current of high tension produced by an electro-dynamo machine; (2) the passage of such current through a number of electrical generators of special construction; (3) the formation of such passage of induced currents, the quality and value of which depend only on the construction of the secondary coils of the electrical generators; (4) the utilisation of these induced currents for the production of light or motive-power. The specification and drawings show that a main wire is to be used for the passage of the current produced by the electric dynamo machine, and that this main wire may be miles in length, and that the electrical generators are to be attached to this main wire where wanted. In the first instance, it was said that there might be an unlimited number of these generators. This expression has been amended, and the word "unlimited" has been struck out. This amendment does not, in our opinion, affect the validity of the patent. There may be as many electrical generators as can in practice be wanted, and that is all that anyone would understand by the use of the word "unlimited" in connection with the rest of the specification. Having stated in general terms what the patentee's system or invention really is, it is necessary to ascertain what according to the original specifications is the most essential element in it. This is the specially constructed electrical generators. It is impossible to read the complete specification as originally drawn without seeing that everything turned on these. The quality and value of the induced currents is said to depend only on the construc-

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tion of their secondary coils, and they are specially claimed by the patentees in their third claim. It is also impossible to read the provisional specification without coming to the same conclusion. It is therefore necessary carefully to study these forms of generators. The electrical generators described in the specification and shown in the drawings are induction-coils. The patentees describe two forms of them. They do not say no others will do ; nor do they point out what in particular is the essential feature of either of them ; but the patentees describe two forms which have certain common features, and there is no reason to suppose that the forms described were not the best known to the patentees when they filed their specification. There is evidence that the forms described will produce the desired results, and there is no evidence to the contrary. Moreover, there is strong evidence that any competent workman could make induction-coils which will produce the desired results by following the specification and drawings, and using such knowledge as he would himself possess. The patentees suppose a main wire 50 kilometres long and a secondary generator—*i.e.*, induction-coil—at every 500 meters. The size of the main wire is not stated. The first example of induction-coil consists of : (1) a central core of soft iron wire capable of being drawn out or pushed into the hollow tube made by the wire coiled round it, and referred to generally. The word in the specification is wire in the singular ; but we understand that any competent workman or electrician would see that a bundle of wires and not one wire was meant, and we so read the specification ; (2) a copper wire about three millimetres in diameter, perfectly insulated in three rows of superposed coils round the core—this is the primary wire, and its length is not stated ; (3) bobbins placed over the cylinder formed as above ; (4) a cable wound round each of these bobbins, and composed of six copper wires of half a millimetre in diameter, each strand being insulated by means of paraffined cotton. This cable of six wires forms the secondary wire of the induction-coil, and its length is not stated. The second example of induction-coil consists of (1) a core like the above ; (2) an insulated primary copper wire, four millimetres in diameter, surrounded by six cables each composed of 12 insulated copper wires of half a millimetre. These cables are the secondary wires, and they are to be arranged parallel to and completely surrounding the primary wire, so as to form with it one cable. The proper lengths of the wires are not stated. (3) The cable thus formed is rolled on a hollow cylinder of wood, say 50 centimetres long and six in diameter ; (4) each layer of spirals is separated from the other by two cylindrical segments of iron two millimetres thick, and without contact to avoid heating ; (5) the extremities of the six fine wire cables are united to a commutator which allows of their being grouped either in tension or quantity. It is apparent, from these two descriptions, that the patentees represent the cable formation of the secondary wires to be important ; quite as important as anything else they described. This, however, is admitted not to be the case. Having thus arrived at the nature of the invention and the mode of carrying it out as described in the specifications, let us turn to the evidence given at the trial. We have studied this with care and have come to the following conclusion : (1) Although some of the specifications in earlier patents come very near the patentees' invention, not of them quite come up to it. No one had previously hit on a combination of (1) an electric dynamo machine producing alternating currents of high tension ; (2) a long main wire ; (3) induction-coils specially constructed, placed along it at intervals for producing light or motion where required. The alleged anticipations all fall short of this. (2) The patentees' system is essentially the combination just mentioned. It was new, apart from the special construction of the induction-coils ; the system is indicated, as Sir William Thomson says, in the drawings to the provisional specification without the letter-press. (3) Nothing really turns on the specially-constructed secondary generators on which the patentees unfortunately laid so much stress. They are not types of any class which has not all their special features. (4) Any competent person, having once seized the idea of the combination shown in the drawings, would see at once how to carry it into effect, and would, without difficulty or further instruction, select an induction-coil suitable for his purpose without adopting either of the specially-constructed coils, and without being told by the specification the lengths of the wires to be used, or the ratio which one of them must bear to the other in length, size, or weight. This is, in our opinion, the true result of the evidence. Any competent electrician would see that a long main wire must, for economical reasons, be as small as circumstances would allow ; that the tension of the current sent along such a wire must be high, far too high to bring into a lamp with safety ; that this tension must be reduced ; that induction-coils could be made to reduce it ; that the lengths and thicknesses of the wires would depend on the object to be attained, and could be ascertained from the law of tension, a formula given in Clerk-Maxwell's book. The evidence, in our opinion, proves all this ; and the state of knowledge was such as to supply the absence of instruction in the specification respecting these details. The nature of the invention is particularly described and ascertained, and two modes of carrying it into effect are sufficiently described to enable any competent electrician who seizes the idea to give effect to it notwithstanding the want of detailed instruction. It is not necessary for us to decide whether the patentees could or could not have obtained a valid patent for their system apart from their specially constructed induction-coils. Perhaps they might have done so. Unfortunately, that was not their intention as originally described. They have so over-estimated the value of their specially constructed generators, and have so drawn and altered their specifications, as to have missed their mark. As already stated, their special form of generator was originally made an essential feature of their system. This was a grievous mistake. They have tried to correct it by amending their complete specification, but in doing so they have entirely changed their front and the nature of their claim. To understand the effect of this amendment it is necessary to see what the patentees have done and what they now claim by their amended specification to be the invention for which they have obtained their patent. The amended specification is vague and ambiguous on this very important point. If confined to a combination of dynamos giving alternate currents of high tension with a main wire and one of the two induction-coils specially described, the patent will be of little or no use to the patentees ; whereas, if construed more extensively, so as to include a combination of such a dynamo with any induction-coil having the properties of the two described, the patent will be of immense practical value, for the evidence shows that any coil which anyone would be likely to make would have such properties. The second of these two constructions is, therefore, obviously that which will be most beneficial to the patentees. It is the construction which the patentees have laboured to maintain. The whole of their evidence was addressed to this. No serious attempt was made to show that there was any merit in the two specially-described generators except their movable iron wire cores, which almost all induction-coils had in 1882. We are satisfied that no other construction is worth contending for, and it is, in our opinion, the true construction of the specification as amended. The specially-constructed generators are no longer claimed, either separately or as essential parts of the combination. They are seen to have no particular value, and are dropped accordingly. This construction of the amended specification renders the patent hopelessly bad in law ; for, first, on this construction the invention is not the same as that described in the provisional specification, but an entirely different invention ; and, secondly, on this construction, the amendment of the complete specification has greatly extended the scope of the patent. As already shown, the essence of the invention, as described in the complete specification in its original shape, and as set forth in the provisional specification, lay in the use of a specially-constructed generator (or combination), which the patentees believed to be superior to all others, and, in fact, to have magical powers ; and if they throw this over they so far depart from their invention as described in these documents as to render the patent they have obtained for it worthless and incapable of being supported. The law upon this point is perfectly well settled, and it is useless to refer to authority for it. This view of the case renders it unnecessary to consider whether the patent could be supported if it were construed narrowly and confined to a combination for an alternating dynamo with induction-coils constructed like one of the two described in the specification. This point was not much argued. The decision in favour of the patentees would be of little use to them, and the petitioners do not care which way it is decided, as they say they do not use that particular combination. This point, if it fairly arose, would, we think, be found full of difficulty, considering the evidence given at the trial. But, having regard to the terms of the specification and the real contest between the parties, we do not think it calls for decision. In our opinion the patent is bad, and the appeal must be dismissed with costs.

COMPANIES' REPORTS.

ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION.

Report of the directors to be submitted to the ordinary general meeting, to be held at the Cannon-street Hotel, on Wednesday, March 13, at 12 o'clock :

In view of the fact that since the date of the last general meeting two interim reports have been issued to the shareholders, the directors consider that the usual *résumé* of the year's work admits of some curtailment in this instance, and they now confine themselves chiefly to a statement of the present position of the corporation, and to an explanation of the yearly accounts. In the special report of the 18th July last, the directors explained in some detail the circumstances attending the litigation with the Edison and Swan United Electric Company in regard to incandescence lamp patents, and reported the decision which Mr. Justice Kay had given in favour of the corporation on the Edison patent. The interim report of the 3rd October last contained a general statement of the position and prospects of the corporation at that time, and of the work accomplished during the first nine months of the year. The directors are glad to be able to announce that the expressions of confidence with regard to the future of the electrical industry contained in their previous reports, are fully borne out by the progress effected during the past year. An extensive and more genuine demand for electric light and power has made itself evident, to the great benefit of the industry generally and to the corporation individually, as will be seen from the satisfactory character of the accounts now presented of the corporation's affairs. It is now generally admitted that the amendment of the Electric Lighting Act of 1882, which extends more favourable terms to the electrical contractors, and thus justifies the investment of capital in central installations for the supply of electric current, will produce highly beneficial results. As a matter of fact, although only a few months have elapsed since the Amendment Bill, introduced by Lord Thurlow, became law, considerable impetus has already been given to the business, and there is now much greater activity in all branches of the industry. The improvement in the general position of the corporation which has followed upon the revival of business in this direction is, however, not yet exhibited in the accounts now submitted, as the orders which have been received, in connection with the supply and erection of plant for central stations, are still in progress. The marked improvement, which is seen from the accounts, is due almost entirely to the growth of the ordinary business. There are also indications that the amendment of the Electric Lighting Act will have a salutary effect in other directions, and by inspiring renewed confidence tend to

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establish a better understanding among the various electrical manufacturers and contractors. United action where common interests are involved is greatly to be desired, and a diminution of the unhealthy competition which has prevailed during the recent depression is necessary to enhance the profits of the business. The formation of an Electrical Trades Section of the London Chamber of Commerce, affording, as it does, opportunities to the principals in the various electrical firms for discussing common interests, is a step in these directions.

The result of the past year's work is, under all the circumstances, highly satisfactory. As compared with the previous year, the volume of business shows an increase of about 38 per cent. and the gross profit an increase of 70 per cent., while the standing charges have increased by only about 7 per cent. The net balance of profit, after providing for depreciation and bad debts, is £12,885. 4s. 9d., which is equal to more than 5 per cent. upon the entire capital of the corporation. It is to be remarked that this profit has been earned almost entirely upon the ordinary transactions of the year, and does not include the profit accruing from the central station work now in hand, and that there are still other important fields from which the corporation are able to derive revenues. The shareholders will therefore recognise that the business of the corporation is now not only established on a reliable profit-earning basis, but that very sanguine expectations with regard to the future development of the business and payment of dividends are justified.

The contracts carried out by the corporation during the year include important work in almost every department of the electrical industry. The lighting of the Melbourne Centennial Exhibition, which proved eminently successful, and comprised the largest installation of the kind yet erected, was carried out almost entirely by means of the corporation's apparatus, supplied at very short notice to the Australasian Electric Light, Power, and Storage Company. The contract secured for the arc lighting of the main building and grounds of the Glasgow Exhibition of 1888 was carried out to the thorough satisfaction of the executive committee, as will be seen from the following letter received from Sir W. Thomson: "As chairman of the lighting committee of this exhibition, I have much pleasure in intimating to you my entire satisfaction with the manner in which your contract was carried out. During the entire period the 520 arc lamps installed by you have worked with the greatest regularity and steadiness." The illuminated fountain installation effected by the corporation at the Barcelona Exhibition formed one of the most attractive features of the exhibition, and was universally described as far surpassing all previous similar undertakings. This contract met with the entire approval of the exhibition authorities, who have given the corporation their highest award of a gold medal. The corporation have also been awarded a diploma in respect of their contract for lighting part of the Brussels Exhibition. Amongst the installations on ships completed by the corporation during the year, may be particularly mentioned those on board the Castle Mail steamers "Rosslyn Castle," "Hawarden Castle," and "Norham Castle." Numerous installations have been carried out in private residences, factories, shops, offices, theatres, and other premises throughout the United Kingdom and abroad, and particular reference may be made to the completion of an important incandescence installation of 1,000 lights at Blenheim Palace, for his Grace the Duke of Marlborough, and also to the lighting of Professor Piazzi Smythe's residence at Ripon. The negotiations with the Honourable Commissioners of Sewers for lighting the City of London have been continued; and it is confidently expected that at an early date specifications will be issued and tenders invited for lighting various sections of the City, for which the corporation will be in a position to submit a proposal with good prospect of success.

The advance in the different technical branches has been of a very marked character, and highly important results have been achieved, notably the perfection of the alternating current system of distribution, which enables electric current to be supplied economically over large areas without any risk of danger to the public. The corporation have designed a complete alternating current system which is now perfect in every detail, and has been in successful operation during the past year. This apparatus has met with great favour since its introduction, and is now being manufactured on a large scale. The Victoria dynamo machine for running incandescence and arc lamps in parallel has been improved in design and mechanical construction, and is generally recognised as one of the most efficient machines for the purpose in the market. This dynamo has been found to lend itself admirably for use in connection with direct driving engines at slow speeds for installation on shipboard, and has been manufactured in large numbers for this application. The special engines supplied by the corporation from the designs of their superintending engineer, Mr. Raworth, meet with a ready sale, and constitute an important feature of the business. The corporation's trade in incandescence lamps has been considerably extended, and their Victoria lamps have secured a wide reputation for durability and economy. When the Cheesbrough patent was upheld by Mr. Justice Kay, in the recent action of Edison and Swan *versus* Holland and others, the corporation at once devoted attention to the production of a lamp in which the Cheesbrough process of flashing could be dispensed with, and their efforts were so successful, that the present form of Victoria lamp ranks as one of the most efficient in the market. The directors are glad to be able to state that the action referred to in the last annual report, which the corporation instituted in 1887 against the Orient Steamship Company, who were using dynamo machines, made by Messrs. King, Brown, and Co., of Edinburgh, in infringement of the Brush patent for compound winding, was decided wholly in favour of the corporation by Mr. Justice Chitty in December last, and the corporation were granted a certificate of validity of the patent, costs, and enquiry as to damages. Meanwhile, Messrs. King, Brown, and Co. have brought an action in Scotland for the revocation of the patent, and this case is now before the Court. With the above exception, every dynamo manufacturer of importance in the country has recognised the corporation's claim, and the royalties now received constitute an important source of revenue. In this matter the policy of the directors has been, while not harassing the trade or interfering with the growth of the industry, to protect the interests of the shareholders by charging a small royalty for the use by others of the corporation's patent. The directors, however, have no alternative but to resort to legal procedure when the usual commercial methods of protecting the corporation's rights, and of enforcing their just claims, fail. The action of the Edison Swan Company against the corporation for alleged infringement of the Edison patent in the manufacture of Victoria incandescence lamps is now under appeal to the House of Lords, the Court of Appeal, which had previously decided in favour of the Edison patent, in the case of Edison and Swan Company *v.* Woodhouse and Rawson, having recently reversed the decision which Mr. Justice Kay gave after a most exhaustive hearing extending over 22 days. In view of the fact that the House of Lords will not be bound by the decision of the Court of Appeal in the Woodhouse and Rawson case, and that the issue to be raised will in many respects be a new one, the directors are advised that there is every prospect of the decision of Mr. Justice Kay in favour of the corporation being sustained. The directors deeply regret the existence of this litigation, which is not only costly, but is a very great disturbance to the proper conduct and development of the ordinary business. Litigation is, however, not always avoidable, and that relative to incandescence lamp patents has been rendered necessary by the action of the Edison Swan United Electric Light Company. That company and the corporation both hold patents for the manufacture of incandescence lamps, and it has always been the earnest desire and endeavour of your directors to respect the interests of the two companies, and of the industry generally, by effecting a settlement equitable and honourable to all parties. In this effort, however, they have not as yet been successful, and have had no recourse but in the interests of the shareholders to defend to the utmost the action instituted by the Edison Swan Company. The corporation have much to gain in the future by freedom from interference in their business as manufacturers of incandescence lamps under the various patents they hold, but, unlike the Edison and Swan Company, they do not rely for their revenue mainly upon the manufacture of these lamps, inasmuch as the corporation's trade in these articles at present amounts to scarcely 10 per cent. of the total volume of their business.

The capital account shows an increase of £4,640, which arises out of the issue, under the resolution passed at the general meeting in February, 1887, of 1,160 new shares. The increase in the patents, development, and goodwill account of £1,749. 1s. 10d. is due to development of new inventions, and to the usual annual payments for maintenance of existing patents. The profit and loss account includes a satisfactory profit derived from the Austro-Hungarian branches. This new department of the business has, during the past year, developed in every way satisfactorily, and bids fair to prove an important source of income in the future. The central lighting stations worked by the corporation are now also yielding good profits. The directors consider the present a fitting opportunity for taking a general survey of the advance made during the five years which have elapsed since the reduction of capital in 1884, and with this view they submit a diagram showing the fluctuations during that period in the volume of the business, the general charges or expenses of management, and the gross profits. To facilitate comparisons between one year and another, the actual figures are shown on the diagram in percentages, the figures for the year 1883 being taken as represented by 100. It will be seen that the volume of business in 1888 is to that of 1883 as 307 is to 100, showing an advance in the five years of upwards of 200 per cent., and while the gross profits have increased in the ratio of 100 to 342·9, or over 242 per cent., the standing charges have fallen in a ratio of from 100 to 65. The above figures do not take cognisance of the business effected through the continental branches. If this be added, as shown in the diagram by means of dotted lines, it will be seen that the advance of the corporation's business is even more satisfactory, notwithstanding that the standing charges are relatively higher on the continent than in England, which is due to the fact that the business carried on there by the corporation is still young; and it is probable that a much larger amount of trade could be effected without any material increase in the expenses of management. The directors think it will be recognised by the shareholders not only that the affairs of the corporation have, during these five years, been conducted with energy and economy, but that, having regard to the hitherto undeveloped condition of the industry, and consequent difficulty and expense of working up a new business, the results must be considered as highly satisfactory and encouraging. With regard to the prospects for the current year, the directors have every confidence in a still further improvement, the orders during the first two months of this year being more than double the orders received during the corresponding period of any previous year.

The directors who retire this year by rotation are Lord Thurlow and Colonel Steuart, who, being eligible, offer themselves for re-election. Messrs. Cooper Brothers and Company, the auditors, also retire, and offer themselves for re-election.

CITY NOTES.

West Coast of America Telegraph Company.—The receipts of this Company for the month of February amounted to £5,900.

Great Northern Telegraph Company.—The traffic receipts of this company for the month of February amounted to £19,600.

Eastern Telegraph Company.—The receipts of this Company for February were £54,611, as against £51,261 for the same period of 1888, or an increase of £3,350.

Eastern Extension Telegraph Company.—The traffic receipts of this Company for the month of February were £37,584, as against £38,795 for the same period of 1888.

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Brazilian Submarine Telegraph Company.—The traffic receipts of this Company for the week ended March 1 amounted to £5,327.

West India and Panama Telegraph Company.—The receipts of this Company for the half-month ended February 28 were £2,696, against £3,201. The November receipts, estimated at £5,203, realised £5,288.

Western and Brazilian Telegraph Company. — The traffic receipts of this Company for the past week, after deducting the fifth of the gross earnings payable to the London Platino-Brazilian Company, were £4,467.

Cuba Submarine Telegraph Company.—The number of messages passing over the lines of this Company during February was 4,151, estimated to produce £3,200, against 4,535 messages, producing £3,666. The receipts for November, estimated at £3,100, realised £3,107.

Anglo-American Brush Electric Light Corporation, Limited.—An available sum of £12,885 is shown in the accounts of the Anglo-American Brush Electric Light Corporation, Limited, for the year 1888, this being inclusive of £2,562 brought forward. The Directors do not propose any distribution.

Direct Spanish Telegraph Company, Limited. — This Company, for the half-year ended December 31, recommend a dividend at the rate of 10 per cent. on the preference shares, and one of 4 per cent. per annum on the ordinary shares, tax free, making, with the previous distribution, a dividend at the rate of 4½ per cent. for 1888 on the ordinary shares, against 4 per cent. in 1887, carrying forward £723. The traffic receipts for the month of February are estimated at £2,008, as against £1,858 in the corresponding period of last year.

Companies of the Month.—The following electrical companies have been registered during the past month :

Graphophone Syndicate, £10 shares	£100,000
Mines and General Telpher Company, £1 shares	4,000
Nottingham Electric Light and Power Company, £10 shares	10,000
River Plate Electricity Company, £10 shares	500,000
Railway Automatic Electric Light Syndicate, £25 shares ...	10,000

PROVISIONAL PATENTS, 1889.

FEBRUARY 25.

3324. **Improvements in the method of and apparatus for operating the carbons of arc lamps.** Frederick Thomas Schmidt, Sunbridge-chambers, Bradford, Yorkshire.

3327. **Signalling by electricity on railways by means of the train in motion.** William Ballard, Bull Ring, St. John's, Worcester.

3330. **Improvement in the application of the electric incandescent light to be used by man or beast.** John Hartness, 59, Campbell-street, Newcastle-on-Tyne.

3345. **Improvements in electric light emitting and other conductors.** James Clegg, 6, Gray's-inn-square.

3350. **An improved instrument for measuring currents of electricity.** Sir Charles Stewart Forbes, Bart., 21, Finsbury-pavement, London. (Complete specification.)

3363. **Improvements in the manufacture of incandescent electric lamps.** John Wigham Edmundson, 46, Lincoln's-inn-fields, London.

3365. **Improved apparatus for facilitating the laying of electrical conductors, chiefly designed for military purposes.** Leo Kamm, 4, South-street, Finsbury, London.

FEBRUARY 26.

3396. **An improved electric checking apparatus for beer engines.** Francis Edward Macmahon, Albany-chambers, Haymarket.

3401. **Improvements in or connected with current regulators for dynamo-electric machines.** Elmer A. Sperry, 1, Quality-court, Chancery-lane. (Complete specification.)

3402. **Improvement in apparatus for metering electric energy.** William Harding Scott and Laurence, Paris, and Scott, Limited, Gothic Works, King-street, Norwich.

3420. **An improved method of automatic regulation in dynamo machines.** Josiah Sayers, 24, Glycena-road, Lavender Hill.

3456. **Electric circuit couplers.** Stanley Charles Cuthbert Currie, 24, Southampton-buildings, London. (Complete specification.)

3461. **Improvements in and relating to electric regulators or balances.** Frédéric Victor Maguaire, 45, Southampton-buildings, London.

FEBRUARY 27.

3499. **Improvements in electrical telegraphs for use on board ship.** Arthur Mechan, 62, St. Vincent-street, Glasgow.

3502. **Improvements in or connected with processes of manufacturing iron wherein the iron is subjected to an electric treatment.** Alfred Griffiths Greenway, Benjamin Franklin Babcock, and Brainerd Radcliffe, 15, Water-street, Liverpool.

3533. **Improvements in the extraction of copper and zinc from their ores, as also of the precious metals contained therein by electrolysis and apparatus therefor.** Charles Denton Abel, 28, Southampton-buildings, Chancery-lane, London. (The firm of Siemens and Halske, Germany.)

3540. **Improvements in electric danger alarms for railway block-signals.** James Henderson Hunter, 191, Fleet-street, London. (Complete specification.)

FEBRUARY 28.

3550. **Improvements in holders for incandescence electric lamps.** Walter Rowbotham, 25 and 27, Sidney-street, Salford, Manchester.

3556. **An improved method of regulating the current developed by dynamos or magneto-electric machines, and the power of electric motors.** Oliver Firth and Edward Wright Crabtree, 27, Kirkgate, Bradford, Yorkshire.

3558. **Method of obtaining aluminium continuously in an electrical furnace.** Henry Kenyon, 3, Kimberley-street, Princes Park, Liverpool.

3569. **Electrical measuring instruments.** J. J. Bowman and V. G. Lironi, Walnut Tree House, High-road, Leytonstone, Essex.

3580. **An improved electric bell or gong.** Frederick Herbert Berry, 186, Fleet-street, London.

MARCH 1.

3629. **Improvements in electric meters.** Robert Snowdon, 70, Market-street, Manchester.

3662. **Improvements in electric railway signals.** Theodore Al'Burtis Putnam, 55 and 56, Chancery-lane, London.

3671. **Improvements in or relating to winding and synchronising clocks by electricity.** Alfred Julius Boult, 323, High Holborn, Middlesex. (René Joseph Pouchard, France.)

3674. **Improved method of and apparatus for distributing and regulating electric currents.** Charles Denton Abel, 28, Southampton-buildings, Chancery-lane, London. (The firm of Siemens and Halske, Germany.)

3679. **An improved apparatus for regulating electric currents and for other purposes.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) (Complete specification.)

MARCH 2.

3687. **Improvements in apparatus for establishing electrical connection, and also for breaking the same at will at any desired distance from the operator.** William Joseph Starkey Barber-Starkey, and Frank Geere Howard, 36, Cleveland-street, London.

3697. **Improvements in the construction and application of transformers for the distribution of electricity for lighting and other purposes.** John Augustine Kingdon, 29, Marlborough-hill, London.

3708. **An improved method for joining electric conductors.** John Kent, 9 and 10, Railway-approach, London Bridge.

SPECIFICATIONS PUBLISHED.

1887.

15,484. **Safety devices for electric circuits.** Cardew. 8d.

1888.

1926. **Mechanical chair for delivering a current of electricity on insertion of coin.** Braun and Lloyd. 8d.
2125. **Arc lamps.** Rowbotham. 8d.
2313. **Dynamo-electrical machines.** De Ferranti. 11d.
2313A. **Dynamo-electrical machines.** De Ferranti. 8d.
2314. **Electrical safety fuses.** De Ferranti. 8d.
2315. **Electrical mains.** De Ferranti. 8d.
2316. **Dynamo-electrical machines.** De Ferranti. 2s.
2420. **Regulating electric currents.** Scott and Paris. 8d.
2654. **Dynamo-electric machines.** Kingdon. 8d.
3550. **Electrical battery.** Thompson. 6d.
4270. **Electro-dynamic motors.** Fiske. 11d.
4425. **Dynamo-electric machines.** Charles and others. 8d.
5082. **Electricity meters.** Sellon and Jackson. 8d.
5259. **Electrically heating rooms.** Capek. 8d.
5528. **Voltaic batteries.** Hermite and others. 4d.
13,145. **Incandescent electric lamps.** Böhm. 8d.
16,959. **Automatic electric contact apparatus.** Hilkier. 8d.
18,245. **Electric lamps.** Coerper. 8d.
18,416. **Measuring electricity.** Jacquemier. 1s. 8d.
319. **Storage batteries.** Kookogey. 8d.
434. **Dry galvanic cells.** Mehner. 4d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	5/8
27 July	10/0	India Rubber, G. P. & Tel.	10	18½
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
26 April	4/0	Reuter's	8	7½
......	...	Swan United	3½	3
12 July	12/0	Telegraph Construction ...	12	42
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15

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NOTES.

Electric Weighing Machine.—An electric weighing machine, the invention of Mr. W. Snelgrove, will be exhibited by Messrs. W. and T. Avery, for the first time, in the Paris Exhibition.

St. Luke's.—The members of the St. Luke's Vestry are considering their electric lighting scheme with the aid of copies of the Parliamentary Bill promoted for this district. The special meeting called for settling the question stands adjourned for a month.

Bermondsey.—The question of electric light was brought forward at the last meeting of the Bermondsey Vestry, and it was resolved to give consent to the applicant company, providing that they agreed to assent to the proposals of the Vestry in relation thereto.

Southwark.—The St. Saviour's (Southwark) District Board of Works have consented to the application for provisional orders on behalf of the Metropolitan Electric Supply Company and the London Electric Supply Corporation, subject to certain restrictions being allowed.

Electricity on the Metropolitan.—The Metropolitan Railway Bill, which empowers the company to use electricity as a motive power, and to enable them to run over the Aylesbury and Buckingham Railway Company, passed the Examiner upon Standing Orders in the House of Commons on Monday last.

Motors for Electric Light.—At the Society of Arts on Wednesday, 20th inst., at 8 p.m., Prof. A. B. W. Kennedy, F.R.S., will read a paper on the "Objects and Methods of the Society of Arts' Motor Trials." The medals awarded at the Society of Arts' motor competition will be presented during the evening.

Edison's Patents in Canada.—The Commissioner of the Patent Office, Ottawa, gave his decision on the 8th inst. in the cases arising from the Edison incandescent patent in Canada. He cancelled the patent on the ground of illegality, and as not being manufactured in Canada, according to the provisions of the statute.

Dudley.—Alderman Bagott is in favour of introducing a competitive system to the gas into the town of Dudley, and at the last meeting begged the Town Council to do all in its power to favour the electric light. At present, however, nothing was determined, but it was agreed to send a deputation to the gas company to endeavour to get a reduction.

Lubeck.—Lubeck, as is well known, was the first town in Germany to have an electric light station of its own. There are now 2,386 incandescent lamps, and 36 arc lamps. The balance sheet for 1888, just published, shows an income of 67,143 marks, and expenditure 45,126 marks. Interest on capital at 3½ per cent., and depreciation at 1 per cent. are given at 15,300 marks, leaving a surplus of 6,717 marks.

Royal Meteorological Society.—Dr. W. Marcet, F.R.S., will deliver an address on "The Sun—its Heat and Light," at 25, Great George-street, on Wednesday next, at 7 p.m., illustrated by experiments, after which the exhibition of new actinometers, radiation apparatus, meteorological instruments. The exhibition will be in readiness for the meeting of the Civil Engineers on Tuesday, the 19th, and will remain open till Friday, the 22nd inst.

Clerkenwell.—At the meeting of the Clerkenwell Vestry, on Monday, an application from the London Electric Supply Corporation and the Metropolitan Electric Supply Company for powers to authorise the companies to acquire lands, erect stations, and supply electricity for public and private use within the parish of Clerkenwell was agreed to, subject to the repair of the roads by the companies for a period of three years.

Floods at Bath.—The electric lighting on the Thomson-Houston system has been started in Bath for some months, with one or two dynamos in a temporary building pending the starting of the new central station. The recent floods, which have caused such extensive damage in the West of England, threatened the destruction of the dynamos at Bath, but fortunately they were able to be moved before the water got sufficiently high to touch them.

Electric Submarine Boat.—A large electric submarine boat is to be shortly constructed in London. The model has been in operation for some weeks at Endell-street Baths, and the syndicate which applied for £20,000 had £90,000 offered yesterday, and will proceed at once with the building a full size boat. The boat is to be worked with accumulators, and the motions of raising and submerging the boat are brought about with three screws.

Electrical Engineers, Students' Meeting.—A meeting was held on Friday, the 8th inst., at 8 p.m., Mr. Guy C. Fricker, A.I.E.E., in the chair. The discussion on Mr. H. W. Handcock's paper on "Ship Lighting and the Aspects of Electrical Industries in the Colonies" was opened by Mr. J. Rance, jun., and continued by the chairman and Messrs. Müller and Childs. Mr. Handcock replied, and a vote of thanks to Mr. Fricker for presiding terminated the proceedings.

Dartford Distributing Station.—A central station is proposed, we hear, at Dartford. The current is intended to be supplied from the Deptford station, but the London Electric Supply Corporation will have enough to do to supply and maintain their London customers, and the current will be hired out to a subsidiary company, who will manage the entire distribution, and themselves be saved the bother of having more machinery to look after than a giant 10,000 transformer or two in a cellar.

Useful Electrical Questions for Tropical Climates.—(1) Is the coefficient of variation of resistance with temperature mathematically correct for copper coils, and more especially for galvanometer-coils? (2) Is capacity variable with temperature? (3) Are high resistance coils of platinum-silver reliable, or is it not a fact that, under certain climatic conditions, they show residual charge—that is, act to a certain extent as a secondary cell, destroying the accuracy of tests?

Competition of Electric Meters.—The competition of electric meters proposed by the Council of Paris for a prize of £100 and other amounts, will take place in June. The meters must be sent, in closed packages with an accompanying notice, on 15th to 25th May next, to the Bureau du Sous-Directeur des Travaux, Hotel de Ville, Paris. In return for the stipulated prizes the Council takes the right to manufacture the meter selected, for use in the municipal central stations in Paris, without payment of further royalty.

People's Lectures.—The lectures by Mr. W. Lant-Carpenter at the Polytechnic, Regent-street, on "Electricity

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in the Service of Man," under the University Extension scheme, have been very successful, about 1,250 attending each time, and some hundreds turned away from the doors. The right class attended, too, being largely consistent of adult artisans. Succinct and reliable syllabuses were given away for the audience to study over at home, giving reference to useful works on the subject for those who cared to take the matter up further.

Chatham.—The Chatham Electric Light Company have been very successful with their station, and the inhabitants are well satisfied with the light. The water supply available was not sufficient, and a well was successfully sunk last week which gives the output of 25,000 gallons per hour. The company have met with considerable success, and they are so satisfied with the progress that has been made in the adoption of the light that it is stated they are now about to make large additions to their plant, for which more capital will be taken up.

Electric Traction in the Ascendant.—Proposals have been made to the Liverpool Tramways Company to install an electrical system without expense over two miles of the Liverpool tramways, agreeing to restore the line if the company are not satisfied with the result. Liverpool ought to be the scene of the next success in electric traction in England. We are getting along at last. Tramway directors are waking up, and the practical working line we illustrate this week should initiate a boom in conductor systems. Storage systems are not behind, as we shall shortly see, and between the two the public ought to travel well.

Electric Engines on the Elevated.—The Daft motor, "Benjamin Franklin," on the Elevated Railroad, New York, has lately drawn nine carriages, the greatest number ever drawn in one train upon the Elevated Railroad. Within the last few weeks experiments with this same engine have also shown that it can draw a load of four goods cars, loaded with railroad iron, with the same ease as a locomotive. The success of this engine is such that a larger and more powerful motor is now in process of construction at the Daft Electric Light Works, which will be able to draw with ease six carriages at a speed of 30 miles an hour.

Alternate Current Motors.—It is whispered that Mr. Ferranti is hard at work on having an alternate current motor ready for the general distribution from Deptford. Two of the four proposed methods of constructing these motors have been tested and discarded; all we can say is that one of the other two, it is hoped, can be adopted practically. The question of efficiency will, of course, settle the question, and if the efficiency is satisfactory we might see a rival tram-line to that we describe this week, run on the high-tension system from Deptford. Some of the directors of the London Electric Corporation are interested also in the series system.

Electric Light at Windsor Castle.—The Queen, says the *Lady's Pictorial*, has expressed her satisfaction with the electric lighting of the corridors at Windsor, and, indeed, the perfection to which incandescent lamps are now brought is irresistible, but her Majesty is still proof against the persuasion of Princess Beatrice to have the light carried into her private apartments, remarking softly to her daughter at the dinner-table a night or two ago: "I am not prejudiced, but at my age it is not worth while changing my habits"—a sentiment not unlike that of the old Kaiser Wilhelm, though his reason for turning down the smoky lamps had more of pathos in it.

Steel Forgings for Electrical Machinery.—During a recent visit to Sheffield we were interested in being shown over the works of Messrs. Moss and Gamble, at Bower-spring and Wadsley, where steel melting, file cutting, and tool-making and heavy steel forging is extensively carried on. Messrs. Moss and Gamble make large quantities of steel forgings of all shapes and sizes for use in engines and electrical machinery, and have for long time supplied Edison, Mather and Platt, W. H. Allen and Co., and other well-known electrical engineers, with best steel forgings. We saw some large steel forgings for Messrs. Allen's engines in progress at the time of our visit.

City Lighting.—At the Bishopsgate Ward Club, on Wednesday, Mr. Laidlaw Cross resumed the subject of electric lighting in the City, and moved, "That the lighting of the City by electric light should no longer be delayed." For some years, he stated, the City had made several attempts or experiments to light it by electricity. There had been several negotiations with different electric light companies, but they had all fallen through. There were now three capable companies ready and willing to contract, and he thought that the hands of the Commissioners of Sewers should be strengthened in their endeavours to use electric light in the City. After a short discussion, the resolution was carried unanimously.

The E.P.S. Co. in St. Martin's-in-the-Fields.—The Vestry of St. Martin's-in-the-Fields, at their meeting last week, passed a resolution granting the provisional order applied for by the Electrical Power Storage Company, under the Electric Lighting Act, for the supply of electricity within the parish, and the Bill will therefore go forward in due course. There has been considerable opposition, but it seems that, after all, justice has declared itself, inasmuch as the field is now once more open. We are not in any way advocating one system more than another, but we are satisfied to note that in this way the balance of power has been preserved, and that, whether it be a question of storage or direct supply, there will at least be fair play, and we await further developments.

An Electric Valve.—An arrangement of electrodes is described by M. Neyreneuf, in the *Journal de Physique*, which the discoverer calls an electric valve, as the current can be passed one way, but not in the other. M. Neyreneuf had been experimenting in electrolysis with aluminium electrodes. With a voltameter constructed with two aluminium electrodes, with dilute acid as electrolyte, and with an alternating current, he found that pure hydrogen was evolved at both electrodes, itself a curious enough result. On constituting an arrangement with one electrode of aluminium and one of mercury, with distilled water as electrolyte, the current was found to pass in one direction only, a somewhat extraordinary result which might possibly prove useful practically for regulation of currents.

Barnet.—Last week we inserted a note under this heading, which must be unreservedly withdrawn. There are always two sides to questions relating to business matters, and in this case we are pretty certain that the reasons why the Statter dynamo is not to be used at Barnet have nothing to do with electrical or commercial efficiency. It is needless to enter into detail as to how a particular note was inserted, but we may go so far as to state that its insertion broke one of the rules which had previously been faithfully followed in this paper—viz., that a technical

journal has nothing to do with purely trade squabbles. Since the note appeared we have received other information regarding this make of dynamo, and, without exception, the users agree that they have found the Statter machine to be a good one.

Willis Electric Ship Signal.—The new electric ship signalling apparatus of Mr. J. B. Willis is much appreciated by marine engineers, and is rapidly becoming adopted for all large vessels. Many of the largest warships have already been fitted with these instruments, and the working has been favourably reported upon, especially from Captain May, of the "Imperieuse," now in Chinese waters. One captain using the Thames frequently, states that with the old mechanical apparatus he used invariably to post men to call orders down to the engine-room, but that now he relies entirely upon his electric signalling apparatus, taking his vessel into dock entirely by its working. On one occasion he was only saved from a certain collision by the smartness with which he was able to transmit orders to the engineer by the electric signaller.

Electrical Presents.—Electric light fittings seem to be becoming fashionable as wedding presents. A recent presentation to the Prince and Princess of Wales by the Colonial Committee, on behalf of the colonies, to celebrate the "Silver Wedding," took the form of a clock and candelabra, with two large wall brackets fitted for electric light. It is an example many technical persons might worthily follow in their own sphere, as marking their esteem and at the same time giving an inducement to their friends to spread the introduction of the electric light in their homes. Wedding presents are not easy to be thought of, and many less pleasing presents than, for instance, an artistic cut-glass, hammered copper, or wrought-iron electric fitting, or the lovely natural foliage "metalli-floral" pendants, lately introduced, might be given to persons living in a district where electricity is likely to be supplied.

Extension of West African Cables to the Cape. On Thursday, the 7th inst., the ss. "Silvertown," Capt. Thomson, belonging to the India Rubber, Gutta Percha and Telegraph Works Company, with about 800 miles of cable on board, sailed from Greenhithe for Teneriffe, *en route* for Bonny (Gulf of Guinea), to lay a cable from that town to the Portuguese island of Principe, and also between St. Paul de Loanda, Benguella, and Mossamedes. The expedition is under the charge of Mr. H. M. Gray, C.E., assisted by Messrs. Theophilus Smith, C.E., Henry Benest, C.E., and Rymer Jones, C.E. Mr. R. E. Peake, C.E., represents the well-known firm of Clarke, Forde, and Taylor, engineers to the companies for which the cables are to be laid. It is expected that communication will be completed in about three months' time. The "Scotia," Capt. Cator, belonging to the Telegraph Construction and Maintenance Company, had previously sailed on Saturday, the 2nd inst., to lay some 1,400 miles further south. When both these groups of cables are laid, the Cape will possess duplicate telegraphic communication with Europe.

Static Electricity and Incandescent Lamps.—Mr. C. S. Bowie, in the *Electrical World*, calls attention to the effect of static electricity in shortening the life of incandescent lamps. In the case he mentions, five lamps, notorious for short life, were situated over some calender rolls. As these rolls generate a good deal of frictional electricity by the passage of the dry paper over them, he was led to believe that this was the cause of the lamps burning out so soon. In order to see what effect frictional electricity had on an incandescent lamp, and also to find a remedy for the above case, a lamp and socket, connected with a cord and attaching plug, was held near a dry fast running leather belt. As soon as the lamp was placed near the belt, the carbon began to vibrate violently—so violently that it was soon broken off. The same effect took place when the current was turned off the lamp. On placing a wire guard, similar to that used over billiard-tables, around a lamp and held near the belt, no effect was noticed on the light or carbon. Wire guards were then placed around the lamps in use near the calenders, and since then there has been no complaint.

Extension at Taunton.—The success of the Taunton Electric Lighting Company, having paid a first year's dividend of five per cent., and a second year's dividend of six per cent., with a balance forward from the two years of £207, has given the directors justification to think that extended working will be equally profitable. They accordingly announce that a further issue of 1,000 shares at £5 will be now made, to enable them to extend their works. A site has been selected at Tangier, near the gas company's works, where a model electric light station will be erected, with new engines of the most economical type. The company employ the Thomson-Houston arc system for the public lighting, and express much satisfaction with the performance of both the dynamos and the lamps. The question of private house lighting, for which there is now a considerable demand in Taunton, will also be attacked. We shall evidently see the efforts of Mr. Massingham result before long in a real central distribution station for public and private lighting in this town. The success achieved by the promoters of electric lighting in Taunton should greatly encourage the various authorities who are anxiously enquiring into the merits of electric lighting.

Electricity v. Gas in Switzerland.—Although it is constantly said (writes a correspondent of *Industries*) that the existing gas works have in no wise suffered by the introduction of the electric light, yet the manufacturers of gas apparatus are complaining of scarcity of orders, there being hardly any new gas works now erected in Switzerland. It is easily understood that the electric light would be preferred to gas in such situations where water power is abundant; but the experience of the last year or two shows that the electric light is cheaper than gas light, even in such cases where the power has to be obtained from steam engines, and hence large manufacturers who have not already a gas supply prefer to put up an electric light installation instead of a local gas plant. In this connection should be mentioned the repairing shops of the St. Gothard Railway, at Bellinzona, which have been amongst the first to introduce the electric light, and this example has stimulated the municipal authorities of Bellinzona, Lugano, and even the small village of Faido, to invite plans and tenders for central electric light stations. In Luek, which receives a splendid new casino, the electric light will be used as a matter of course. A large billiard factory in Berne has also been fitted up with the electric light, and the same illumination is employed in the town theatre of Zug; and these examples might be multiplied to any extent. It is remarkable that the incandescent gas light, although a year or two ago it appeared to give much promise, has never taken a firm hold in Switzerland.

Westminster.—At a meeting of the St. Margaret's and St. John's (Westminster) Vestry, on Wednesday, Arch-

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deacon Farrar in the chair, the Parliamentary Committee reported that they had had the following electric lighting schemes before them: Kensington and Knightsbridge Electric Lighting Company, Metropolitan Electric Supply Company, London Electric Supply Corporation, Westminster Electric Lighting Company, St. George's (Hanover-square) Electric Lighting Company, and the House-to-House Electric Light Supply Company. They recommended that objections should be lodged agianst the whole of them. The committee further reported that they had received communications from the Board of Trade notifying that the Board had refused the applications for licenses by the Metropolitan Electric Supply Company and the London Electric Supply Corporation, on the ground that in matters of such magnitude Parliament should be afforded an opportunity to review the Board's decision. The committee was still proceeding upon the reference by the Vestry, empowering them to fully enquire into the whole question of electric lighting, with a view to the Vestry undertaking the supply of the light in that district themselves. A letter was read from the secretary to the House-to-House Electric Light Supply Company, inviting the Vestry to inspect the works at their Kensington Electric Lighting Central Station, adjoining West Brompton Station, and now in working order, and offering to explain their system for the guidance of the Vestry in dealing with the electric lighting question. On the motion of Mr. J. B. Batten, this invitation was referred to the Parliamentary Committee; and the foregoing report and recommendations were unanimously adopted, at the instance of the same gentleman.

Electric Light in a Hydropathic.—Among Scotch health resorts, Crieff, in the valley of the Earn, has always held a foremost place. It is largely patronised by the residents of Glasgow, Edinburgh, and Dundee, and among hydropathic establishments, that of Strathearn House, Crieff, has become the best known, and is the most frequented of any, even in midwinter having usually over 100 visitors. It is not therefore surprising that the directorate should desire to add to its other attractions that of the electric light, which is admirably suited to such an institution. At the beginning of the present year it was decided to lay down plant capable, not only of lighting the public rooms of the building itself, but also of supplying current to several motors scattered about the outbuildings, and to one or two villas adjacent. Amongst other things, it is intended to supplement the water-power driving a threshing machine in the stables by means of an electric motor. The power is supplied by means of a double-acting high-speed Griffin gas-engine of 24-brake h.p., nearly running at 200 revolutions per minute, which drives a Paris and Scott dynamo, giving 100 volts and 120 amperes. The engine-room is underground, and close by it is the accumulator-house, where it is intended to place 54 of the E.P.S. Co.'s largest cells to increase the capacity of the station. A main switchboard in the engine-room, and a controller in the manager's office, give complete control over the number of lights in use. All circuits are protected by Anderson and Munro's fusible cut outs and safety switches. The lamps are either the Sunbeam lamps of 400 and 200 c.p., or the usual Edison-Swan lamps of 16 c.p. The rooms at present fitted are the drawing-room, dining-room, ladies' boudoir, gentlemen's room, recreation hall, billiard-room, offices, and lobbies. There are inside the main building over 150 lamps already wired, and these displace a rather larger number of gas jets. The work has been undertaken under the direction of Mr. C. H. Yeaman, electrical engineer, of 40, Prah-road, London, N, and Glasgow, for Dr. Meikle, managing-director of the establishment.

Cheltenham.—The Electric Lighting Committee at Cheltenham, on February 26th, submitted a report advocating the introduction of the electric light. Estimates had been invited for a combination of public and private lighting on the basis of 60 arcs of 1,200 c.p. (36 being required for street lighting), and 2,000 16-c.p. incandescents. From particulars and information thus received the committee arrive at the following conclusion: That motive power, generating machinery, circuit, lamps, and other plant sufficient for 60 arc lamps of 1,200 c.p. each, and 2,300 incandescent lamps of 16 c.p. each, including £1,800 estimated cost of site and buildings, can be erected for £11,900. This estimate is based on the circuit being partly underground and partly overhead. On the assumption that the whole of the arc lights will be alight on an average nine hours per night; and that the incandescent circuit has pressure on for 18 out of 24 hours, the incandescent lamps being supplied by meter, and alight on an average 1,500 hours each per annum, the annual cost of the production of this light, including repairs, maintenance, depreciation, and interest and repayment of capital, will be from £3,300 to £3,700 per annum. Assuming that 2,000 16-c.p. incandescent lamps yield an income of about ¼d. per lamp per hour, and 20 arc lamps are let out at £15 per annum each, your committee estimate that the cost of the 40 public arc lamps would be under £250 per annum. As will be seen, the number of lamps in the foregoing calculation is below the number which the plant is designed to supply, and as the demand for light increases the income will increase accordingly, which will allow of a proportionate extension of the public lighting at no greater cost. The committee estimate that 40 arc lights would render unnecessary 180 of the existing gas lamps, which at the present reduced price per lamp would cost about £450 per annum. A saving of £200 per annum would, therefore, be effected in the public lighting, while the power of the light would be many times greater. There are two sites belonging to the Corporation, either of which would be available for a station—namely, Barrett's mill, and the land purchased for the erection of the destructor. The latter has the advantage of access to the railway, thereby slightly reducing the cost of the coal, but the former is more central, and, on the whole, your committee recommend the adoption of that site, a course in which they are confirmed by the representatives of both the firms they have been in communication with. The committee having given an approximate estimate, ask to be allowed to proceed with the matter and procure tenders to be submitted to the Council. A meeting of the Council was held on Monday last, and Mr. Norman, in an able speech, a model in point of view of accuracy of statement and lucidity, pointed out the advantages of the scheme discussed, and the report in detail. The speeches of Messrs. Griffith and Lawrence supplemented this. An amendment to the adoption of the report was proposed, but the opponents were many of them in favour of the lighting, the opposition mainly arising from timidity as to the success of the scheme. The report was finally carried with four dissentients, amidst some applause, and tenders will be invited. As Cheltenham is the only town, except Bradford, where the Corporation is going to become vendors of electric energy, this decision is of very considerable importance.

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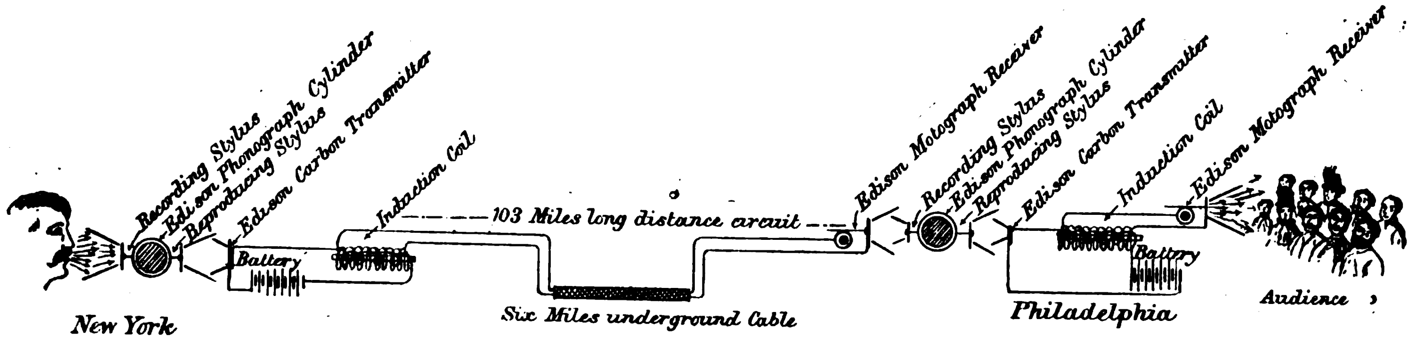
A PHONOGRAPHIC AND TELEPHONIC EXPERIMENT.

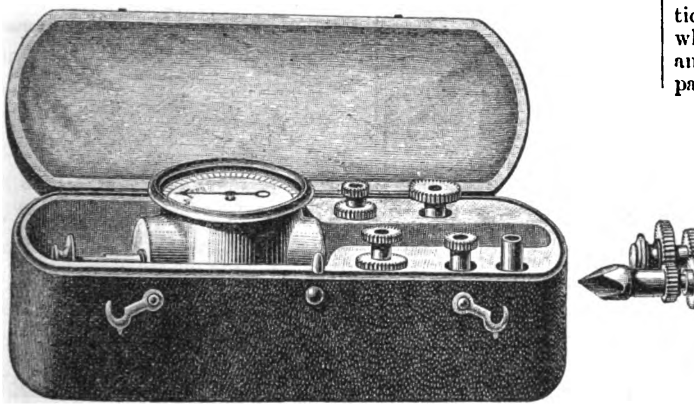
Mr. W. J. Hammer, a gentleman almost as well known on this side of the water as in America, recently gave a lecture upon "Edison and His Inventions" at the Franklin Institute, Philadelphia, in the course of which he carried out an extraordinary experiment illustrating phonographic and telephonic transmission between New York and Philadelphia. This experiment has been referred to and illustrated in various English papers, but in every case inaccurately. Some days ago we received from Mr. Hammer—who, by the bye, will soon be welcomed by his friends on this side, as he is coming to the Paris Exhibition —a description of the experiment, and from the drawings the illustration given herewith has been prepared. The illustration almost explains itself. It employed two Edison phonographs, two Edison carbon telephones, two Edison motograph receivers or loud-speaking telephones, two induction-coils, two sets of batteries, and 103 miles of long distance telephone wire—six miles of which was underground cable. These mediums included glass, iron, and mica diaphragms, composition of wax cylinder, of chalk cylinder, carbon buttons, steel stylus, palladium-faced pens, copper wire, and air. The experiment shows three of Edison's remarkable inventions working in juxtaposition—his carbon transmitter, his motograph receiver, and his phonograph. A successful experiment of so complicated a kind speaks volumes as to the excellence of these pieces of apparatus.

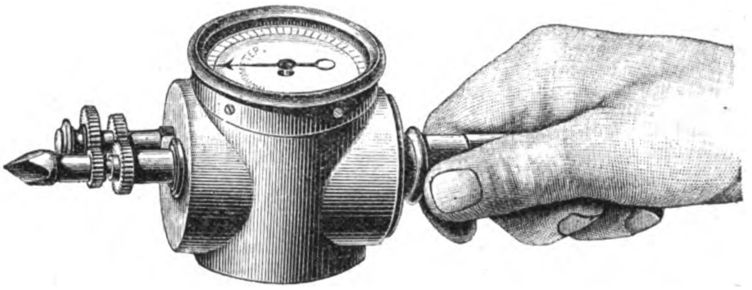


Phonographic and Telephonic Experiment.

POCKET TACHOMETER.

For all manner of electrical engineering, testing, and for laboratory work with dynamos and motors generally, the possession of a good and easily readable pocket speed indicator is a pressing necessity. There are several specimens of fairly practical speed-counters now in use, but, unfortunately, the "counting," with most of these has to be done by the observer, the instrument merely recording the number of revolutions on a dial of figures. For some work, such as the counting of the revolutions of engines, this kind of speed-register is specially required, but for experiments or tests where the speed of rotation is required, an instrument showing this by direct reading is greatly preferable. Instruments of this type, under the name of tachometers, constructed to indicate directly and continuously the precise speed of rotation, are now generally used in electric light installations connected permanently with the dynamos. Messrs. Schaeffer and Budenberg, makers of these tachometers, are now introducing a pocket tachometer of the same type, but very much smaller, which is intended to be used by hand. It is very light and portable, and the actual speed of revolving shafts, in revolutions per minute, is indicated upon a dial face with the same accuracy as the larger instruments.


Pocket Tachometer in Case.


Schaeffer and Budenberg's Pocket Tachometer.

The pocket tachometer is employed in the usual way, by holding it with a slight pressure of the hand against the end of the rotating shaft, so that the steel bit provided on the spindle end of the apparatus enters the centre mark of the shaft. The instrument will then indicate directly and continuously the precise speed of rotation of the shaft. The instrument is ordinarily divided up to 1,000 revolutions per minute.

For use with higher or lower speeds than those for which it is graduated, two sets of small toothed wheels are supplied, which can be quickly attached, and by this means the relative speed of the tachometer can be increased to double or reduced to one-half the ordinary indication, the speed of the shaft being then obtained by simple multiplication or division of the readings by two. The instrument, with its toothed wheels, is fitted, as shown, in a neat leather case, and should prove exceedingly useful to electrical engineers.

NATIONAL ELECTRIC LIGHT ASSOCIATION (AMERICA)—MEETING AT CHICAGO.

Our American contemporaries have had one of their periodical meetings, at which they have once more shown the intense practicality of their ideas. At these meetings—which savour somewhat of the character of the half-yearly meetings of the Iron and Steel Institute or the Institution of Mechanical Engineers—papers on practical subjects are read and discussed. Part of the proceedings is of interest only to electrical engineers in America; another part has a wider interest, and appeals to all in the profession whether practising in America or any other part of the world.

Instead of attempting to reproduce the papers and discussions, which other demands on our space forbids, we shall endeavour to give the gist of them, believing this will best meet the requirements of our readers. The abstract is made from the full and excellent reports of the *Electrical World* and the *Western Electrician.*

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The PRESIDENT (Mr. S. A. Duncan), after referring briefly to the history of the organisation, suggested that the question of the day is the electrical distribution of power. The progress made during the year by the electrical industry was shown by the following table, the figures of which were analysed in reat detail:

—	Feb., 1888.	Aug., 1888.	Feb., 1889.	Feb., 1888, to Feb., 1889.
Central station and isolated plants ...	4,000	5,351	5,747	—
New central stations and isolated plants	—	1,351	716	2,067
Per cent. increase of central stations and isolated plants	—	32·3	13·5	50·1
Arc lamps	175,000	192,500	219,924	—
Increase of arc lamps.........	—	35,201	27,424	62,625
Per cent. increase of arc lamps	—	20·1	14·2	34·3
Incandescencelamps	1,750,000	2,142,440	2,504,490	—
Increase of incandescence lamps ...	—	392,944	361,546	754,490
Per cent. increase of incandescence lamps	—	32·3	16·7	49·0
Increase in capitalisation of electric light companies..	—	$42,210,100 Total.	$27,187,634	$69,397,744 Total.
Electric street railways in operation.	—	34	Inc. 19	53
Electric street railways being built..	—	83	Dec. 39	44
Electric street railways incorporated but not yet contracted for.........	—	39	Inc. 3	42
Electric cars in operation	—	223	,, 155	378
Electric cars under contract; roads not yet finished...	—	244	,, 185	329
Miles of single track in operation	—	138	,, 157·5	294·5
Miles of single track under contract, not yet in operation	—	189·5	,, 84·25	273·75

An exhibition of apparatus in connection with the meeting was referred to as an important feature, and attention was called to the papers to be read, and the satisfactory financial position of the association, which showed a balance to the good of over 2,500dols.

The first paper was the report of the Committee on "Patent Legislation," read by Mr. A. STEUART, which recommended the passage of the Bill to establish a Court of Patent Appeals.

The jurisdiction of the court as prescribed as defined in the Bill is as follows:

Section 14. The Court of Patent Appeals of the United States shall have appellate jurisdiction in the cases hereafter specially provided for without regard to the sum in controversy:

1. From the courts of the United States having original jurisdiction of cases touching patents, copyrights, trade marks, and labels, in all cases involving these subjects.

2. From the Commissioner of Patents in all cases touching the patentability of inventions, priority of invention among several claimants for patents upon the same invention, and in all cases of reissue and the judicial practice of the Patent Office; also all cases touching the registration of trade marks and labels and the rights of conflicting claimants therefore.

Section 15. From and after the passage of this Act there shall be no appeal from the Circuit Courts of the United States or any territorial or district court or courts of the district of Columbia, in cases touching patents, trade marks, copyrights, or labels to the Supreme Court of the United States directly, but all such cases formerly appealable to the Supreme Court shall be heard on appeal by the Court of Patent Appeals.

Section 16. There shall be a right of appeal from the Court of Patent Appeals to the Supreme Court of the United States in all cases, regardless of the amount in controversy, subject to the same regulations, however, as now exist with regard to appeals to the Supreme Court in causes of Admiralty and maritime jurisdiction, and to such further regulations as the Supreme Court of the United States may make.

Section 17. All cases touching patents, trade marks, copyrights, or labels now pending before the Supreme Court of the United States awaiting trial shall be transferred to and heard by the Court of Patent Appeals.

Mr. E. T. LYNCH read the report of the Committee on "Underground Conduits and Conductors." The report was based on 120 answers received by the committee to the following questions:

1. Have you ever placed underground any electric light conductors carrying currents at a potential of 1,000 volts, or over?
2. If so, state the number of experiments, giving the date of each?
3. What was the length of each individual conductor laid underground?
4. What was the voltage on each conductor?
5. What was the current, in amperes, carried by each conductor?
6. What make and style of dynamo supplied the current on each of these conductors?
7. Were these conductors single, or grouped in cables?
8. How many conductors to the cable?
9. What was the size of the conductors used? (In answering this question give the number and gauge.)
10. What was the thickness of the insulation?
11. Who was the maker of the cable?
12. Were the cables laid in any form of conduit?
13. If so, what kind of conduit was used?
14. Describe the manner in which the cables were laid in the conduit; whether drawn in, built in, or otherwise?
15. If the cables were laid directly in the ground, describe the method of laying them.
16. Was there more than one duct in the conduit?
17. If there were other ducts, what was in them?
18. Did you have exclusive control of the conduit?
19. What was the total duration of your experiments?
20. Did the cables work satisfactorily during the entire time of your experiments?
21. If not, how long did they work satisfactorily?
22. If the cables failed to work satisfactorily, to which of the following causes do you attribute the difficulty? Please answer as fully as possible:

a. Defective insulation?
b. Defects in joints?
c. Defects in making connections from cables to lamps?

First: The writer has used the underground conductors for three years. Has used wire of three of the most prominent manufacturers. Has discarded two, and is now using the third.

The cables were carried in a cement pipe, and manholes were placed at every 250ft. Cables had been drawn into the conduits, and as a method of facilitating their drawing in, pulverised soapstone had been used for the purpose of avoiding abrasion.

Only one wire placed in each pipe.

He states that the wires have not worked satisfactorily, and that he has been compelled to shut down many times; that they are now running fairly well; but he is obliged to keep them under constant supervision and repair.

He accounts for most of the trouble that he has experienced by defective insulation, defective mechanical construction, and by deterioration in the insulation in the wires, having had no serious trouble with the style of conduits that he has used.

In answer to the question regarding the practicability of placing his conductors underground, he states: "We are operating some eight miles of underground wire; we wish there were less, and certainly are not anxious for more."

In answer to the question regarding the difficulties and objections to underground wiring, and whether he considers them commercial, electrical, or mechanical, he states:

Electrical.—There is no cable that will last with a current from a 50-light dynamo. Commercial.—Owing to the large cost of construction, and expense of maintenance, and great possibility of breaks. There is consequently poor service and dissatisfaction. He has exclusive control of his conduit.

Second: The writer has made many experiments, in which he has used lengths of cable varying from 200ft. to two miles in length, manufactured by most of the prominent wiring companies. Cables have been laid in and drawn in his own conduits, conduits constructed both of wood and iron. The tests have usually been of short duration, and have been suspended in each case after a failure of the cable to work satisfactorily. The cause of the failure has been mainly defective insulation. Defective mechanical construction, defects in laying, defective conduits, injury to cables in laying or defective joints, have caused very little trouble, the main cause of trouble being in defective insulation and deterioration owing to the presence of gas, water, and steam.

His opinion, based upon the results brought out by the many tests that he has made, is that he does not consider it practical at the present time to place conductors underground, the absence of insulation that would stand being the principal reason. If ever that question is settled the cost would, in his estimation, make it commercially impracticable. In only one instance he had the exclusive control of the conduit.

Third: The company represented by the writer had four circuits underground for about one year. One style of cable only, manufactured by a prominent manufacturer, was alone used. The wire was drawn into a composition conduit, which had manholes at the corners.

Quite an amount of trouble was caused in the start off by difficulty caused by abrasion to cable in drawing the wire into the conduit. The experiments were continued for one year. They caused a great deal of trouble with the lighting contracts, and at the end of that time were abandoned. He considers his chief troubles to be defective conduits, water in the conduits, and deterioration of the cables; also trouble in defective insulation, defects in the joints and trouble in making connections through iron pipes from the conduit to the surface.

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His opinion, based upon the results of the tests that he has made, is: "That he does not consider it practicable to place his wires underground," and he states, "I do not know of any system that has yet proved satisfactory." And further states: "I know of no system to-day which, even at any expense, has proved satisfactory, except a system of subways built large enough for men to walk through their entire length."

In answer to the difficulties of placing wires underground, he states that he considers the difficulties to be commercial, electrical and mechanical in perfection, and still not be so expensive (in the end) as to make the commercial objection insurmountable. "We are all in the business simply to make money, and the commercial objection must be met just as much as any other." He did not have exclusive control of the conduit. The ordinance passed by the Common Council in his city in 1886 stated "that their committee had examined the subject, and found the putting of all electrical wires underground feasible, and ordered all wires within a few months, and those outside of this district, underground within one year." He has been brought before the court a number of times on complaint of the City Attorney, but nothing yet has been done in the matter.

Fourth: The writer has made two experiments during the last summer, one of which was a failure, and the other a partial success, though the duration of the second test and the position it occupied in the circuit was such as to give little importance to the result. The wires were pulled into a wooden conduit, there being two ducts in each conduit. Cables did not work satisfactorily. He states that the failure is due entirely to defective insulation.

In answer to the question if he considers it practicable to place his conductors underground, he replies, "We do not, with any system known at present."

In answer to the last question, concerning the difficulties and objections to placing wires underground, he states: "The difficulty is particularly commercial, though I have seen no system which I think will properly insulate the conductors."

Fifth: The writer has placed two circuits underground, about the first of the present year. The cables used are those manufactured by six of the most prominent companies. They have been drawn into an asphalte conduit, twelve ducts in each conduit. The duration of his experiment has only been about a month and a half, and he states that it is too early to tell what will be considered the result of the experiment.

In answer to the question if it would be considered practicable to place the wires underground, he states: "Have seen nothing yet that will answer."

In answer to the question regarding his opinion concerning difficulties and objections to going underground, he replies: "Chiefly commercial, partly electrical and partly mechanical." He has exclusive control over his own style of conduit.

Sixth: The writer has had wires in the conduits for about five years. The mains were carried through the streets in a composite system of conduits. The connections are made from the system to the cellars through iron pipes, and the wires are conveyed then through cellars, connection being made from the cellars to the houses. These cellars run completely around the block, and permit of access to them for the purpose of repairing or making connections to wires.

He has used three different kinds of wires in the conduits, the cables now in use having been in position for about thirteen months; although he has had trouble with them, he claims that satisfactory service can be maintained in his particular locality, and he considers the question of the distribution of power and light an exceedingly simple one in his city, which is probably the only city that is so fortunately situated.

He has, in all, about 32 circuits. He states that he is on the right track regarding the placing of wires underground, and that the system such as he operates will run satisfactorily. The cables that he is using are guaranteed for three years. The trouble that he had with his first wires was mainly due, as far as he can ascertain, to the fact that the insulation surrounding the wires was not of sufficient thickness, and the main conduits themselves were not dry. He controls his own conduits exclusively.

Seventh: The writer has made some practical experiments and tests with cables under water; these were manufactured by two of the most prominent companies. The cables did not, however, work satisfactorily, lasting, as they did, from three months to one and a half years. He lays the cause of failure to the effect of water upon the cable, and the deterioration in the insulation of the wire. His opinion, based upon the tests he has made, is that he does not consider it practicable to place his conductors underground. Considers that the difficulties are both electrical, mechanical, and commercial. Had exclusive control over such conduits as he used.

In summarising the results of the experiments in these cities, in one case only did the electric light company place its wires underground willingly. In all others they were forced to do so by the local authorities.

In only one instance have the experiments or practical workings proved satisfactory. The only other case that they did not report adversely, being where the wires had only been in operation about 40 days. The average voltage that they have used on all the circuits tested was 1,893 volts; the current was 10 amperes. The average thickness of insulation over wires was $\frac{5}{32}$ of an inch, and the average length of cables tested in each case was about 4,600ft.

In considering the second class of answers, namely, those who have not yet made any extended practical test, their answers have been directed mainly to the last four questions, the first two of which relate to action by the municipal authorities, and the last two consider the practicability and the difficulties of placing wires underground. In very few of these cities have the municipal authorities yet taken any steps towards action upon the matter, having been delayed in awaiting the solution of the underground question in other cities.

In answer to the question asking them if they considered it practical to place their conductors underground, 104 have replied that their opinions based upon tests that they have seen and such information as they have been able to obtain, both in this country and abroad, is "that it has not been practical to place the wires conveying high-tension electric arc light currents underground."

Two have answered that they considered it practical to do so, but state that at the present time they have no wires underground.

In answer to the question which asks their opinion regarding the greatest difficulties to be met with in considering the placing and operating of underground wires, they all unite in the opinion that "the difficulties are both mechanical, electrical, and commercial." They consider that the question of obtaining a satisfactory conduit has not been properly solved; and that even if that should be solved in the future, that we cannot even at this time obtain a satisfactory insulation for the wires that will not deteriorate within a few years, and become perfectly useless as an insulator when subjected to the action of steam, water, and gas. The great difficulty of making connections for buildings and lamps, and the absence of any satisfactory system of subsidiary conduits, is considered by all as a bar to successful operation, as the difficulty of drawing in cables without abrasion to the insulating covering, even with the most careful handling, is very great.

The commercial objection is considered a very great one, as not only is the first cost about eight times heavier than that of an overhead system, but the repairs to the cables due to the deterioration of the insulation and other defects caused by mechanical or electrical deficiences would be very much heavier than the expense of operating and maintaining overhead systems, and that the prices at which they are now furnishing the electric light would have to be very materially increased to meet these extra and very heavy expenses. A system of tunnels through all the principal streets is considered to afford the only means for the solution of this problem. . . . .

Other companies reply that the wiring of their system that has been used for underground purposes has been for potentials under 1,000 volts, and that they have met with entire success with potentials of a system with 1,000 volts. And they do not anticipate in the future that they will have any trouble in furnishing wire to meet the requirements of the electric lighting companies, but at the present time they have not yet done so. They unite in stating that they think that the question of the insulation of high voltage of currents should be solved by the using of good durable thick insulation. Their experience in conduits has been that they do not want creosoted wood, but would prefer to have their wires buried in the ground or under water, and would recommend at the present time that single conductors should be used. They seem to be about evenly divided on the question as to whether lead-covered cables should be used for underground purposes.

In the discussion, Prof. BARRETT, of Chicago, had used underground conduits for six years; result satisfactory. Mr. W. H. JOHNSTONE referred to its use in Philadelphia "with perfect and uniform success," to conduits now being used in New York and said "Mr. Lynch would have to reverse that report in a very short time." Mr. ECCLESINE believed that "they will be compelled to go underground by public opinion." Mr. T. C. SMITH argued that by overhead wires, if properly carried out, was the best way of distributing power. Mr. LOCKWOOD had tried underground cables with current of from 1,800 to 2,000 volts and had given them up. Mr. B. E. SUNNY said:

We put through our cables all the way from 2,000 to 3,000 volts, and sometimes go higher. Of course, I cannot say how long the cables that we have now, that have been in use for just about a year, and have only given us four cases of trouble—I cannot say how long they are going to last, or how long they are going to furnish that satisfactory service, but just at this time they seem to be in first-class condition; they are doing all for us that we expected they would, and we are perfectly satisfied with them. Scientifically, it is all right. The only objection we have is a financial one. I made up some figures a few days ago, and I find that it is costing us the difference to furnish this service from underground conductors as compared with aerial conductors about as follows: Circuit reconstruction and maintenance of conduit amounted for three months to 9,610.95dols. That was for 1,194 lamps for eight hours a day for 90 days, or 959,680 lamp-hours. You see the cost of underground conductors is a trifle more than 1 cent. per lamp-hour over and above what it would cost on an aerial conductor. Now, you will say if we had nothing but aerial conductors we would still have the item of circuit reconstruction. This is very true, but I have left out the question of underground conductors so far as the repairs on electrical machinery are concerned. It is no question in our minds at all but that we are put to 200dols. or 300dols. expense every month on account of repairs to the electrical apparatus that are made necessary owing to our underground cable, so that I think it is perfectly right to say that if our wires were on poles in the streets the troubles I have enumerated would be eliminated. We figured, therefore, that from a scientific and practical standpoint underground cables are all right. From a financial standpoint they are costing us one cent. per lamp-hour here more than aerial conductors. The conduit rent is 1,000dols. per year per duct. The duct will hold three electric light cables; so that the rent per mile for each conductor is about 333dols. 33 cents. The item of circuit reconstruction—9,610dols.—included going over the joints in manholes, pulling out some sections of cable, and replacing, taking out, and renewing some wires under sidewalk; it included everything that we did with the plant that we could not charge to construction.

Mr. E. A. SPERRY also had satisfactory experience with an underground system current at 1,800 volts. Other speakers prophesied failure where conduits were used. Letters were

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read from Mr. W. Hochhausen and Prof. Elihu Thompson. Both lacked decision: it may or it may not—wait a little, get more experience, and then—business expediency, go gently—and so on. Result of discussion: everybody started with his own opinion, and kept it.

ARC LAMPS AND THEIR MECHANISM.*

BY PROF. SILVANUS P. THOMPSON, D.SC., M.I.E.E.

An arc lamp being an apparatus for transforming the electric energy supplied to it through the conducting wires into heat and light, it obviously cannot be expected to give a steady illumination unless it can be so arranged and operated that, in the first place, the rate at which it appropriates and transforms the electric energy is constant, and that, in the second place, the circumstances attending this transformation (in respect of the triple relation between the quantity of heat evolved, the degree of temperature, and the emissivity of the incandescent surface) also remain constant. The first of these two provisos relates to the operation of the system of lamps and dynamos (or other means of electric supply) acting conjointly; the second of them relates solely to the quality of the carbon pencils used as electrodes.

As the latter is a simple matter, it may be disposed of first. Suppose the pencils to be composed of a homogeneous carbon, the physical properties of which, such as hardness, specific thermal capacity, conductivity for electricity, conductivity for heat, emissivity, etc., are constant; also that they are cylindrical and of given diameter. Then it follows that if energy is being expended at a uniform rate in heating the tips of a pencil it will be maintained at a uniform temperature, and the amount of light emitted per square millimetre of the surface will be constant, and, as the section is constant, the rate of consumption constant, and the pencil homogeneous, the form once acquired by the incandescent tip (whether positive crater or negative peak) will remain constant. It may be remarked, in passing, that the researches of Captain Abney have shown that the white light of the incandescent carbon surface of the crater at the positive pole of the arc is always of precisely the same composition in respect of the relative proportions of waves of different colours. This most important observation indicates beyond doubt that the temperature of the actual light-emitting surface is always the same. Indeed, this ought to be the case if the latent heat of vapourisation of carbon be a positive quantity. When the surface attains this temperature, a volatilisation begins; and when so begun the temperature cannot rise further, any more than ice can be raised above its temperature of fusion. The limiting temperature of the voltaic arc is the temperature of volatilisation of the material of the electrodes. This is, in itself, a reason why the introduction of all known foreign substances whatsoever into the carbon pencils of the arc is found to lower its intrinsic brilliancy; for all known elements have a lower temperature of volatilisation, and all compounds are dissociated at arc temperatures.

If, then, we may assume homogeneity of the carbons to be used, the steadiness of the arc light will depend solely upon the maintenance of a steady rate of appropriating and transforming electric energy. How a want of homogeneity may be compensated for in the actual working of the lamp is a point reserved for consideration later.

The rate at which electric energy is appropriated from the wires, and transformed in the lamp into heat and light, always depends both upon the construction of the lamp and upon the conditions imposed upon the system of electric supply. This is a mere consequence of the fact, well known to every electric engineer, that the amount of electric energy per second appropriated by any electric device, motor, or accumulator, is itself the product of two quantities—the current and the pressure (or potential) at which the current is supplied. To put the matter in electrician's language, the number of *watts* of electric energy per second appropriated by the lamp† is equal to the number of *amperes* that flow through it multiplied by the number of *volts* that may be applied as a difference of potentials between its two terminals. To keep constant the *product* of the amperes and the volts is the practical problem which the mechanism of the arc lamp must be designed to solve.

A point of much theoretical interest, and in reality of great practical importance, is the fact, long disputed, now established beyond question, that the arc itself does not act simply as an added resistance in the path of the current, but exercises also a counter E.M.F., and tends to set up an opposing current. The apparent resistance of the arc resembles that of an electrolytic cell, or that of an electric motor when running, or that of a thermopile when a current from an external source is passed through it. The current which flows through the arc arouses, by a species of polarisation, an opposing E.M.F. The simplest fact in proof of this is that, unlike any ordinary conductor, the apparent resistance of the arc is not proportional to its length. The apparent resistance of an arc two millimetres in length between the carbon tips is not double that of an arc one millimetre in length, nor anything near double. The fairest way to investigate the matter is to make a series of experiments with arcs of different lengths, the current being independently so regulated as to be maintained of the same strength in each case. There appears to be a true resistence proportional to the length, and a back E.M.F., which in steady arcs, and with currents of from seven to fifteen amperes, appears to be about 38 to 39 volts. When the arc hisses, as often happens if the length of it be very short, the back E.M.F. fluctuates very much, but always drops to something under 20 volts. Except in the case of constant-current circuits, this causes a sudden increase of current when the lamp begins to hiss, and it may be noticed that the light, though unsteady during hissing, is brighter at the negative pole of the arc.

Hitherto all guesses as to the cause of this counter E.M.F. have been very vague, not to say wild. To account for 39 volts of polarisation on any hypothesis that it is due to electrolytic or thermo-electric action, is to suggest causes which are, to say the least, wholly inadequate. The explanation which for the past two years I have been in the habit of suggesting to my students, and which has not been otherwise published hitherto, is as follows: Every reversible phenomenon which the current can itself produce, and which requires an expenditure of energy for its production, necessarily implies the exhibition of a counter E.M.F. One has only to look at the cases of the reversible chemical action in a cell, of the reversible magneto-mechanical action of a motor, the reversible heating effects of a thermo-electric junction, to comprehend this. Now the phenomenon of volatilisation is a reversible one: give to the solid carbon at its volatilisation temperature the necessary latent heat, it is changed to vapour; take from the vapour its latent heat, it condenses back to solid carbon. The arc under normal circumstances is the seat of an actual evaporation of carbon at the positive pole, as well as of a combustion at both poles. So far as any data exist, it appears that the excess of carbon consumed at the positive pole by an ordinary continuous current, is about 0·5 grammes per ampere-hour. If we knew the latent heat of volatilisation of carbon per gramme we could calculate *à priori* the necessary minimum E.M.F. at the positive pole, which would obviously represent the counter E.M.F. so far as it is situated at that point. With long arcs the excess of consumption of the positive pencil over that of the negative is both less and more regular than that which occurs with short arcs. With short arcs three other phenomena occur which are important in this connection. Firstly, the short arc is liable to whistle or hiss, giving evidence of instability; secondly, it frequently gives rise to "mushrooms," or irregular growths of carbon upon the apex of the negative pencil; thirdly, when it hisses, the counter E.M.F. becomes very unsteady, but appears to have an average value about half that of the steady long arc. It is worth while to throw out the suggestion, that the condensation of carbon at the negative pole, in the short arc, is accountable for the change in E.M.F., and for the instability which manifests itself by the hissing sound.

Passing from these conjectures to the construction of lamps for the production of light by the arc, we are now prepared to lay down the points which must be provided for in every arc lamp. It must be emphatically pointed out at the outset that, as the performance of a lamp depends upon the conditions under which it is supplied with electric energy by the circuit, the design of the lamp necessarily also depends on those conditions. In the present state of the art of electric distribution we may classify the conditions of electric supply under the following heads:

I.—CONTINUOUS SUPPLY AT CONSTANT POTENTIAL.

In this case the arc lamps are arranged either simply all in parallel

* Paper read before the Society of Arts, March 6th.

† Strictly speaking, the actual number of *watts* utilised in the arc is somewhat less than the whole number received from the supply, as a portion of the energy is expended in passing the current through the regulating coils, and another portion is lost in consequence of the resistance offered by the pencils of carbon themselves, and is merely expended in warming them. We may calculate the former loss as follows: Let E represent the whole number of volts from terminal to terminal, and let i represent the whole current supplied, then the whole number of watts supplied is Ei. Let the *ohms* of resistance of the regulating coils in the main circuit be called a, and that of the shunt-coils be called b, that of the carbon pencils themselves c, and that of the resistance-coils sometimes used in the main circuit to steady the arc, r. Also, in the case where the lamp has a shunt circuit, let the portion of i which passes through the carbons be called i_1, and that which goes through the shunt, i_2; so that $i_1 + i_2 = i$. The losses are then as follows:

$$ai_1^2 = \text{watts lost in main circuit coil;}$$
$$bi_2^2 = E^2 \div b = \text{watts lost in shunt-coil;}$$
$$ci_1^2 = \text{watts lost in warming carbon pencil;}$$
$$ri^2 = \text{watts lost in the resistance coil.}$$

The resistance of carbon pencils is usually small, and may be materially reduced by a thin coating of copper. The carbons used in commerce (11 to 15 millimetres in diameter) vary from about 1·15 to 0·2 ohms per foot, if plain, and from 0·001 to 0·09 if coppered. Cored carbons have a higher resistance than uncored. Carbons cut from solid gas-coke have from five to twenty times as much resistance as those made by the usual modern processes. When lamps are run in series, the resistance offered by the pencils is of more importance; for example, a set of 50 lamps newly trimmed with long carbons may offer 25 ohms more resistance than when all the carbons have burned down short. The resistance, a, of the regulating coils that are in the main circuit differs in different lamps, but may be taken at from 0·05 to 0·2 ohms. The resistance, b, of the shunt-coils is seldom less than 200 ohms, and may be as much as from 400 to 500 ohms. Of the volts, E, applied to the lamp only a part is utilised, the lost volts being accounted for by the resistances in the path of the current. If these are deducted from the applied E.M.F., there will remain a certain number of volts, which we may call e, which are available as a useful difference of potential at the arc itself. To measure e directly, one has only to apply a voltmeter, making the contacts of its two leading wires to the two carbons at points respectively just above and just below the incandescent tips. The watts actually utilised in the arc are then calculated as the product ei_1. As shown above, e is less than E, and, indeed, may be considerably less, the lost volts depending upon the resistances introduced, and on the current flowing through them. If E is constant, e will not necessarily be so, but will be very nearly if i is also constant. Also i_1 is less than i in all lamps that have a shunt regulating coil, but is not usually more than from 3 to 5 per cent. less than i, so that in the cases where i is kept constant, i_1 will be nearly so also.

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or in parallels containing two in series; the currents being divided by mains and branches to the lamps. At least 55 volts should be allowed between the mains for single arcs. Practice shows that arc lamps in parallel burn more steadily if a resistance wire of ·25 to 1·0 ohm be included in the lamp circuit. Taking the back E.M.F. of a steady arc at 39 volts, it is obvious that the excess of the volts at the mains over this represents the volts used in driving the current through the actual resistance in the main circuit of the lamp. This resistance consists of four parts—the true resistance of the arc itself, which may vary from $\frac{1}{15}$ to $\frac{1}{2}$ ohm; the resistance of the carbon pencils, which averages about 0·15 ohm per foot per plain carbons; the resistance of the main-circuit coils, which varies in different lamps from 0·05 to 0·2 ohm; and the resistance of the wire introduced for steadying the lamp. In a 10-ampere lamp, working at 55 volts at the mains, 16 volts remain, after deducting 39 for the back E.M.F., and these 16 are approximately distributed as follows: two volts in the arc itself, three volts in the carbons (say 2ft. long in the total), one volt in the main coil, and 10 volts in the steadying resistance.

II.—Continuous Supply with Constant Current.

In this case the arc lamps are arranged in series, the whole of the current going from one lamp to the next, and returning to the dynamo after having traversed successively all the lamps. This is *par excellence* the arc light system of distribution, the parallel system at constant potential requiring heavier mains. As the lamps arranged in series tend to steady one another, it is not necessary to allow more than 45 to 50 volts per lamp, including the ordinary lengths of cable from lamp to lamp. From 5 to 10 amperes is the usual current for arc lamps in series.

III.—Alternating Supply at Constant Potential.

In this case also, the lamps are usually arranged as in the first case, the only difference being in certain structural details, such as lamination of iron cores.

IV.—Alternating Supply with Constant Current.

This case can hardly be said to be practical, though alternate current dynamos, capable of supplying six or eight lamps in series, have been constructed in past years.

The supply systems, whether continuous or alternating, must be assumed, for the purpose of this paper, to perform efficiently what they profess—namely, to maintain constant one of the two factors of the electric power which they supply to the distributing system. In each case it remains for the mechanism of the lamp to effect such adjustment as will maintain constant the other factor of the product. If the condition of supply is "at constant potential," then it is for the lamp itself so to adjust its carbons as to keep the current through the arc constant. If the condition of supply is "with constant current," then the lamp must adjust its carbons to maintain between them the requisite potential. Hence the differences which are necessary in construction between those lamps which are to work "at constant potential" (in parallel) and those which are to work with constant current (in series). These differences, as will now be shown, chiefly affect the "feeding" mechanisms of the lamp.

In discussing the necessary mechanisms of arc lamps, no further reference will be made to lamps of the Jablochkoff candle type, nor to those with abutment blocks of marble ("Sun" lamp, etc.), nor to the so-called incandescence arc ("semi-incandescent") lamps, nor to those with curved carbons (Heinrichs's type), nor yet to those horizontal carbons (De Mersanne's, Solignac's, etc.).

Necessary Mechanism of Arc Lamps.

[A.] *Driving Power.*—In every lamp some means or mechanism is required to propel the carbons towards one another as they burn away, gravity being by far the most common agency for doing this.

[B.] *Striking Mechanism.*—In every arc lamp it is requisite to provide a mechanism for bringing the tips of the carbon pencils into contact, and then parting them asunder to the requisite distance across which the arc or flame plays. If, as in most lamps, the carbons are in contact when the lamp is out of action, then a mechanism is required simply to part them as soon as the current is turned on. The operation of producing the arc by parting the carbons is known as "striking" the arc. The mechanism must be automatic, so as to come into action not only when the current is first turned on, but at any subsequent time if from any cause the arc fails. An adjustment, *b*, of the striking mechanism is also usually added to permit of regulation in the length of the stroke or initial distance between the poles.

[C.] *Feeding Mechanism.*—As the carbons burn away, one or both of them must be propelled forward to maintain the arc at its proper size. This action is called "feeding" the arc. This action ought to take place by small and imperceptible amounts, and as the rate of consumption of the carbons is continually varying, even with carbons of the best modern manufacture, the lamp must itself regulate the rate at which the pencils are propelled forward in automatic correspondence with the consumption for the time being. Further, since the presence of soft and more readily volatilised portions in the pencils seems to be unavoidable, provision ought to be made so that, whenever the pencil burns down to such a portion, causing a sudden increase in the volume of the flame or arc—technically called a "blower"—the mechanism of the lamp ought at once automatically to draw apart the pencils to a slightly greater distance. A lamp which has a *retractile* motion in either its feeding or its striking mechanism is superior to one that has not, as it can be used with cheaper and less pure brands of carbon. An adjustment, *c*, for regulating the frequency or range of the feeding movements is usual.

[D.] *Replacement Mechanism.*—When the pair of carbon pencils has burned away, the lamp trimmer has to replace the stumps by a new pair of long carbons. In order to admit these, the carbon-holders must be pushed apart to their widest extent. Special mechanical devices for allowing this motion to occur have to be provided in some forms of lamp, whilst other forms need no special device.

[E.] *Moderating Mechanism.*—To prevent the carbon from making too sudden motions, it is usual to add a moderating device, such as a dash-pot, or, in the case of those lamps in which there is a train of wheels, a fan or a governor.

So far, the devices enumerated have been such as are common to all classes of lamps. Those which follow are only required in particular types of lamps.

[F.] *Focussing Mechanism.*—In all those cases where it is desired that the luminous points should occupy a fixed position in space, some additional mechanism is necessary to make the arc lamp keep its focus. In lamps designed for the mere lighting of area, this is not important, and in the vast majority of these the upper carbon descends whilst the lower carbon (the negative) is fixed: the luminous point slowly shifting downwards as the carbon consumes. All devices for causing the carbons to move forward at such relative rates as to keep an approximately fixed position for the arc will be discussed, together with their methods of adjustment, *f*, under the heading of focussing mechanism.

[G.] *Change over Mechanism.*—Lamps that must run for many hours continuously must be supplied with two pairs of pencils, because it is neither practicable nor advisable to use pencils of extreme length. In the double lamps it is appropriate to provide such arrangements as shall cause one pair of pencils to come into operation first, and when these are consumed away, shall change-over the action, either by electical or by mechanical devices, so that the second pair of pencils shall come into operation.

[H.] *Cut-out Mechanism.*—Lamps intended for series working must be provided with some contrivance to prevent the extinction of the whole series when from any cause there is a failure of the light in any one lamp. The usual device is a sort of automatic relay arranged in connection with each lamp, to come into operation in the event of its failure, the operation of the device being (1) to cut the faulty lamp out of circuit by simply short-circuiting it, or (2) to substitute for it a wire of suitable resistance, or (3) to replace it by an auxiliary lamp. The device for performing either of the two former operations is technically known as a "cut-out."

Supplementary Contrivances.

In addition to the eight distinct species of contrivances above enumerated, there are numerous details which might be further classified; such, for example, as devices for *clamping* the carbon pencils to their respective holders in true allignment; devices for raising and lowering the lamps. For these, however, there is no space. Neither is it possible to enumerate the devices which have been suggested (Staite, Siemens, Brockie, Andrews, Crompton, Swinburne, and others) for *compensating*, in lamps whose action depends on the weight of the descending carbon pencil and its holder, for the diminution of pull as the pencil is consumed.

Schedule of Mechanisms.

A schedule embracing the eight heads above enumerated, if supplemented by statements of the gauges and resistances of the wires used in the windings of the coils, affords a systematic and very convenient method of tabulating the facts concerning the construction of any arc lamp. An example of such schedule, filled up with the data of one arc lamp of recent pattern, is given at the end of this paper.

Electromagnets for Arc Lamps.

As the electromagnet plays so essential a part in the striking, feeding, and cut-out mechanisms of lamps, a short digression upon the particular forms of electromagnets appropriate to arc lamps is not out of place. The ordinary treatises on electricity have little to tell about the special properties of different forms of electromagnet; indeed, this all-important organ in modern electrical engineering has received very inadequate attention from writers on electricity. It is a familiar fact that the attraction of a horseshoe-shaped magnet, whether of steel or iron, varies very greatly with the position of the iron armature, being great at small distances, but very rapidly falling away as the intervening space is increased. To devise a form of electromagnet whose attractive power shall be exerted over a fairly long range was at one time one of the practical problems of electricians, and it has been solved in various ways. The attraction which a solenoid, or tubular coil, exerts, when transversed by a current, upon an iron core introduced within its aperture, is not, in any position of the core, nearly as great as that exercised by an electromagnet of horseshoe type, constructed of equal amounts of metal, and energised by an equal current. On the other hand, the feebler pull of the solenoid upon its core is exerted through a very extended range. And by making the core of conical form, or by winding the coils of the solenoid in a conical fashion, it is possible still more completely to equalise the pull over a long range. Solenoids with cores are used in several well-known types of lamps in which a long travel is required. On the other hand, since the operation of striking the arc requires a short motion not exceeding one-twelfth of an inch, or two millimetres, in all those types of lamp in which a special electromagnet is used simply to strike the arc, a form of electromagnet is required which will exert a powerful pull over a short range. Further, for working certain clutch mechanisms and the like, it is desirable that a form of electromagnet should be found which, whilst having a travel of, say, one inch, should exert throughout the whole of that range a fairly strong pull, increasing of course toward the end.

(To be Continued).

Book Received.—"Transactions of the American Institute of Electrical Engineers," vol. V., containing a report of eleven meetings, from September 20th, 1887, to October 9th, 1888. Published by the Institute, New York.

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NOTICE.

During the course of the past year we issued steel engraved portraits of Mr. E. Graves, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. Wollaston, M.D., F.R.S., *and* Sir Humphry Davy, F.R.S. *The portraits of* Prof. D. E. Hughes, F.R.S., *and of* Dr. J. Hopkinson, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

FASHION IN ELECTRIC LIGHTING.

The paper of Mr. Kapp before the Institution of Civil Engineers and the discussion thereon seems to give an opportunity for reflection as to thoughtlessly following the prevailing fashion which, for the moment, finds favour with electric light engineers. The two great electric lighting systems are respectively the direct and the alternate current systems. Each has its advantages and its disadvantages from the lighting contractor's point of view. With every desire to find favour with those actively engaged in electrical matters, we are compelled occasionally to point out that their education is extremely defective, for very few are mechanical engineers. The majority have no experience of mechanical engineering, and because they can gabble over some formulæ, and drive the real engineers into a corner by quoting Ohm's or some other law, they imagine that what they do is and must be right. The rising and purely scholastic electrician is a poor animal—too conceited to understand his weakness, and too ignorant to do aught but disagree with what anyone else does or proposes. He is a shade worse than the pure mathematician, who cannot act till some practical man puts the data into his hands, and then his soul is in arms to show that some torm having an infinitesimal bearing upon practical work is shelved by the rough-and-ready workers in the shops.

Let us try and see ourselves as others see us, and ruminate how far the strictures made are warranted by the facts of the case. The mechanical engineer believes in machinery, well designed and well made for the purpose of doing the work it is expected to do. But he also expects that when his machinery is constructed it is going to be worked and not lie idle. He laughs at breakdowns. He does not duplicate his mill engines because they may perhaps break down. He drives his ships through nine or ten thousand miles of water and expects his engines to work smoothly and comfortably. He is prepared to produce engines that shall stand the wear and tear of central station work, and not make much fuss about it. He goes on pumping day and night, week in and week out, and thinks very little about the matter. Thus he looks upon the electrical engineer, who makes dynamos that are expected "more or less" to break down, as a man who does not know his business. From the engineer's point of view, there is no reason why a well-designed and well-constructed dynamo should break down. Overheating, breaking down your insulation, etc., are "bugs" that ought not to be possible. Overheating means bad designing or bad construction, too little copper, metal possibly where it ought not to be, and no metal where it ought to be. Breaking down insulation is primarily due to similar causes, and to dust and dirt or other foreign matter getting where it ought not to be—which again comes to bad design.

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This is a small part of what mechanical engineers tell us.

Come we now to a central station designed upon the alternate current system. Our real engineer asks if all that machinery is put down just to be able to do the maximum work one or two hours out of twenty-four, and to lie idle eleven-twelfths of its time. Prudence, and a dislike to be laughed at, inclines us to prevaricate, but mendacity does not pay with these gentlemen, so reluctantly we acknowledge the fact to be as stated. We have dinned into our ears once more the rule that guides the engineer. Work your machinery all you can, don't let it lie idle. Work and make money, otherwise pay heavily for idle plant. The commercial man listens, thinks, and says, Why, only about one-fifth of your power is pretty constantly at work, and really has to earn your dividends—if any are earned—while four-fifths of your plant are idle four-fifths of the time. There ought to be some wonderful compensating advantages for all this; and so there are, says the electrical engineer. By this device we save largely in our mains, being able to work at a higher pressure, transforming down at the houses to a workable or rather to a safe pressure in the houses. Both engineer and business man agree that there is something in this, and want to know more, till their questions again become rather hard to answer with any degree of satisfaction. The cost of laying is about the same one way or the other. With the lighter cables and higher voltage, the insulation is more costly, and forms a practical set-off. The leakage, if leakage there is, forms a greater percentage of the whole, and so the amount saved has not that rosy appearance one is accustomed to take for granted when the doctors recommending the system put forth their views. Finally, the weak link in the system is laid bare. One piece of apparatus would put it right. In order to use the greater part of our machinery constantly, power as well as light *must* be distributed. An economical alternate current motor would work a revolution in this system. Then it might be put down without fear and trembling, whereas at present—and *if* such a motor is not forthcoming during the next ten years—the money spent upon alternate current stations is heavily handicapped in dividend earning. Given the motor, all is plain sailing. We had hoped to have heard this phase of the question threshed out at the Civil Engineers, but the discussion took almost entirely a professorial strain concerning details about which the practical man and the business man care very little. These men want to know if there is any prospect of strengthening the weak link. It needs no electrical knowledge to see that the Tesla motor, as exhibited and explained by Prof. Ayrton, is practically valueless, and though rumours exist as to improvements made, and also to the effect that Mr. Ferranti has designed a successful motor, we are fain to doubt the correctness of both rumours. There is no possible doubt but the most important invention required for any purpose whatever in the whole world at the present moment is a good-working, economical alternate current motor. The man who invents such a machine will rank far above Watt, or Gramme, or Edison, and will command a fortune such as no American speculator ever dreamt of—that is, supposing half-a-dozen inventors do not hit upon equally good machines at the same time. Meanwhile, the undue extension of alternate current systems is detrimental to the industry generally, not to lighting specially, inasmuch as the distribution of power, and consequently the manufacture of motors, is a minimum.

THE SERIES ELECTRICAL TRAMWAY AT NORTHFLEET.

For some little time the tramway world generally, and that part of the electrical engineering profession interested in tramway and traction work, have been more or less on the *qui vive* to ascertain the practical outcome of the project undertaken at Northfleet, to open the first electrical tramway in Europe worked upon the "series" underground system.

Profs. Ayrton and Perry in England, in conjunction with the late Prof. Fleeming Jenkin, and working with practical electrical engineers, have developed successfully the series system, with overhead wires for goods transport, under the name of the telpher system; while Prof. Short has carried the principle of series working of tramcar motors into actual operation with considerable success in America. The patents of Ayrton and Perry and Fleeming Jenkin, controlling series working, have been acquired by the Series Electrical Traction Syndicate, Limited, of 11, Queen Victoria-street, E.C. This syndicate, working in conjunction with the enterprising United Electrical Engineering Company (Messrs. Manville and Madgen, managing directors), and the syndicate's consulting engineer, Mr. Joseph Kincaid, M.I.C.E., have developed the scheme into a practical system of tramcar working suitable for English towns, which it was our pleasure to inspect, with other representatives of the technical press, on the opening ceremony on Wednesday.

Advantages of Series Working.

The possible systems for tramway work for towns in this country are limited, practically, to the two systems of (1) accumulator cars carrying their own battery, and (2) lines with underground conductors in conduits. Tram lines with overhead conductors are greatly favoured in the new cities of the United States, and these may be practicable in certain situations in England, as for country tramway work, for electrical subways, and eventually for heavy electric railways proper, as proposed for the Metropolitan; but for towns the two first-mentioned systems are alone allowable. With the underground conduit

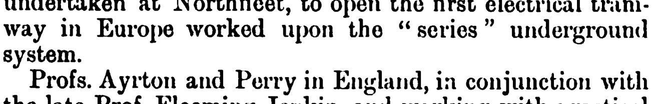

Fig. 1.—Diagram of the Series System.

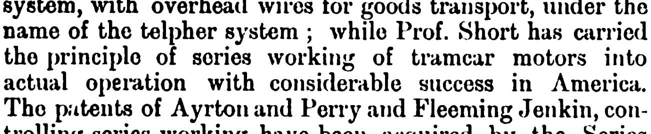

Fig. 2.—Electrical Connections.

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system there are the two methods of running the electric motors which move the cars: either in parallel from a pair circuits. The great, the enormous advantage of the series system of running is that the copper cable for the tram

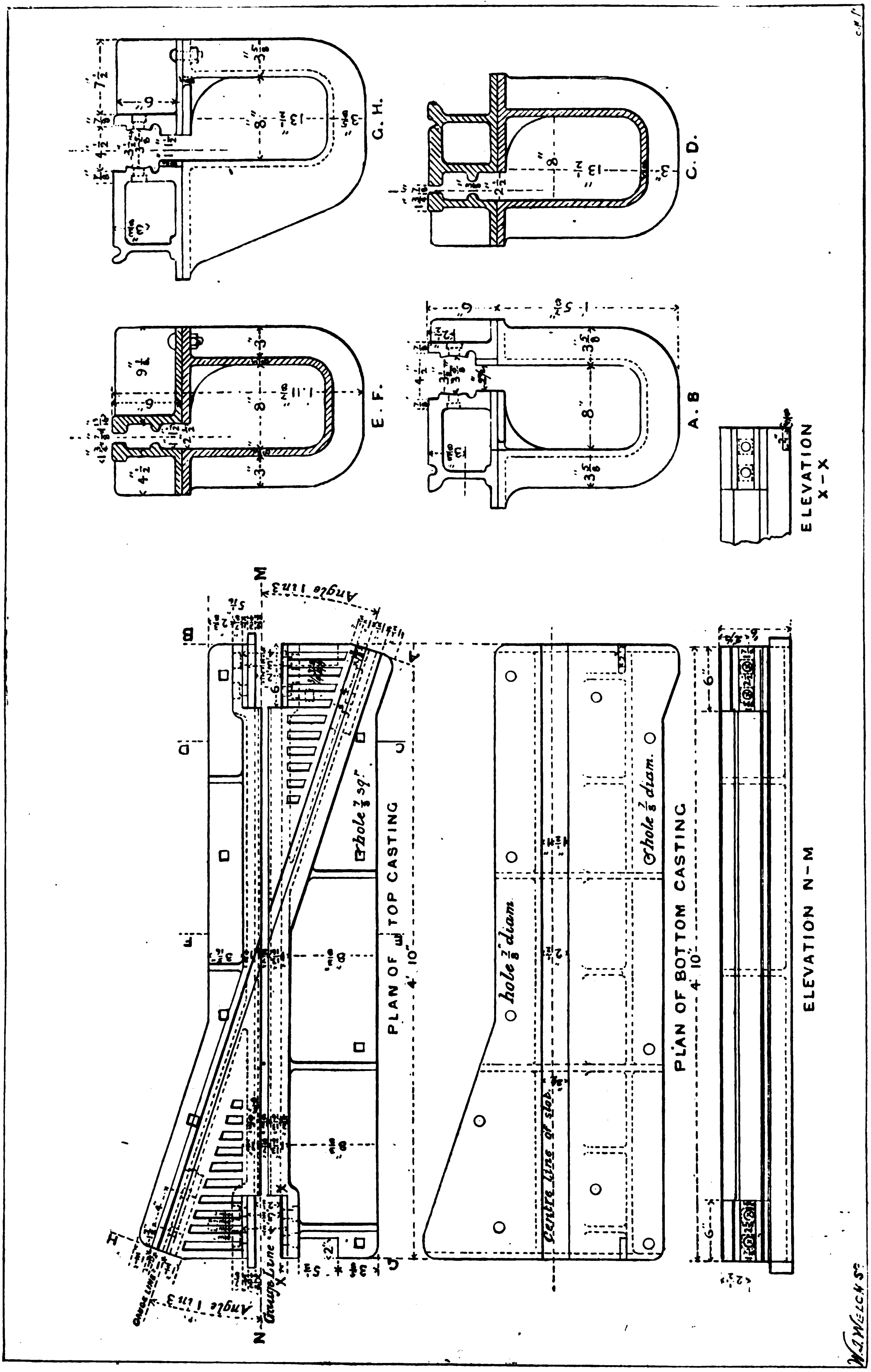

FIG. 3.—The Series Tramway at Northfleet. Details of the Line and Conduits.

of mains, or in series—that is, one after the other upon a single wire (with an unbroken return wire)—as in arc lamp line needs to be only of sufficient diameter to carry the current for a single motor instead of for the whole number,

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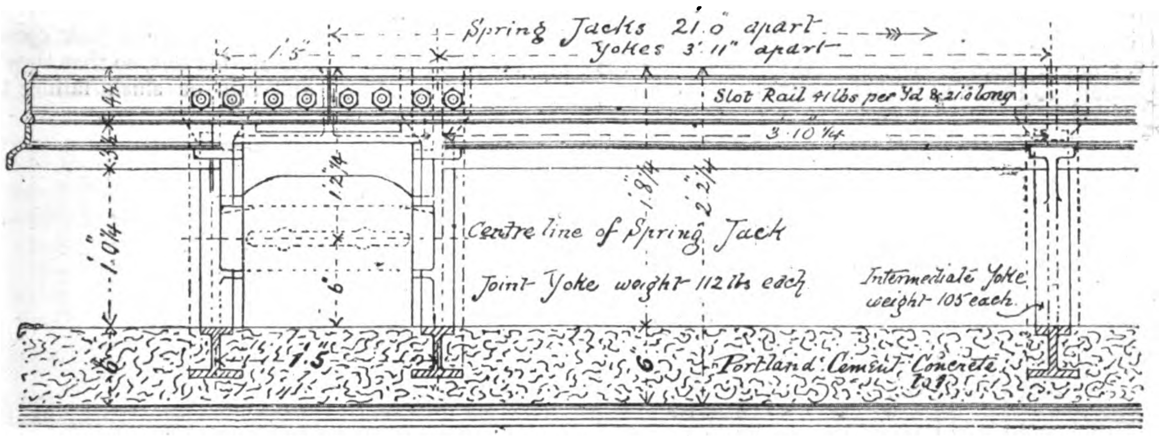
as the same current passes through every motor consecutively, and the saving, both in outlay for copper and in waste of energy in the mains, is vastly in favour of the series method. The objections, on the other hand, are that a very high pressure is needed in the mains to send the current through the whole series, making insulation proportionately difficult, and that if any accident occur to the line that whole series of cars is deprived of motive power. The tramway now opened has been built to show the practicability of running electrical tramcars in series with one another. In the construction of this line it is claimed that the details, both electrical and mechanical, are worked in such a manner as to overcome all the difficulties of insulation and of working, resulting in an underground conduit system, which will be practically applicable to existing or proposed tram lines along the town streets, on a method which ensures by far the most economical employment of electricity.

To make clear the economy of transmission of power by electricity on a line five miles in length by series working as against parallel working for heavy horse-power, such as would be used in railway working, the following instance is given. The electrical pressure now used at the terminals of a motor may be taken at 200 volts. For the transmission of 400 h.p. to the centre of the line of five miles at this pressure, with a conductor of very large area, say, of a resistance of 0·15 ohm per mile—equal to a weight of three tons of copper per mile—the initial power required at the further end would be 2,500 h.p., the difference being lost in resistance of the mains; whereas, with series running with the same pressure of 200 volts at each motor, about 405 h.p. would be required at the engine-house. With a greater pressure—say, 400 volts—the loss, of course, would be much less in the parallel system; but beyond a certain point it will not be safe to raise the pressure at the motors, and the saving in transmitting the power where many cars are running on the same line, will always be greatly in favour of the series method.



LONGITUDINAL SECTION THROUGH SLOT

Fig. 4.

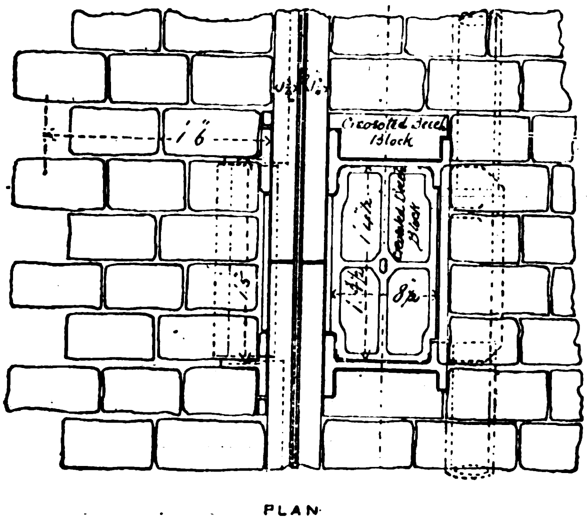
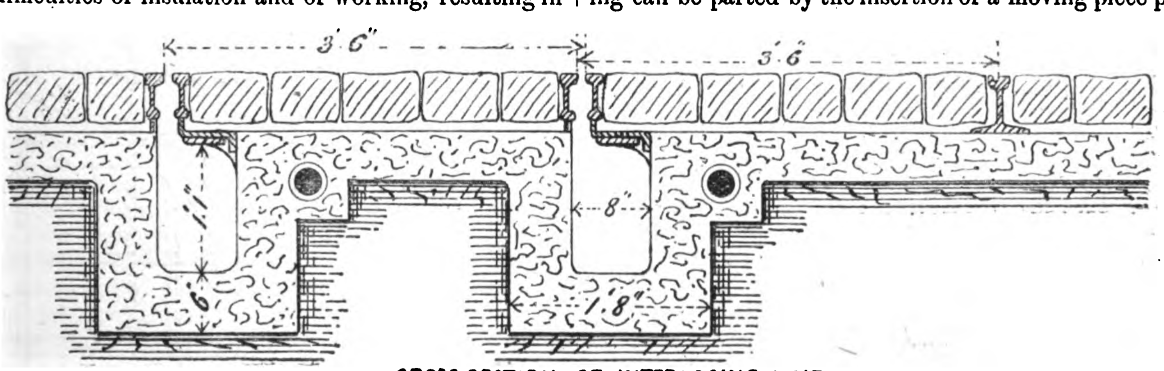


Fig. 5.—Spring Jack Box.



CROSS SECTION OF INTERLACING LINE

Fig. 6.

The Principle of Series Traction.

It may be well, before describing the details of the Northfleet tramway, to mention briefly the principle upon which the cars in series are worked according to the patents before mentioned. Granting a line of two or more cars whose motors are in series, we require a dynamo producing an electrical pressure equal to the total pressure required for the whole of the motors added together. We require also a conductor leading the current along the tram line for taking the current to the motors, and a return wire to lead the current back to the machine. We require, besides this, arrangements for interposing in the first-named conductor, contacts to lead the current into the motors at any point all along the route, which must be done without breaking the metallic circuit of the whole line. The principle is illustrated in the accompanying diagram (Fig. 1), where a number of spring contacts normally touching can be parted by the insertion of a moving piece projecting from the car, which enables the current to be led up into the motor and back to the contact without breaking the circuit. The method of joining up the contacts is also shown (Fig. 2), where B, B, are the spring contacts, and the long double line turned over at its end represents diagrammatically, in plan, the moving contact which is fixed to the car, and projects down into the conduit. The lines 1 and 2

represent copper strips, which are, in practice, mounted on a long, thin insulating strip termed the "arrow." The strips turn round the end of the arrow, but do not meet at 3, 3, and the two strips are connected with the motor. The spring contacts—termed "spring jacks"—are connected electrically, as shown by the curved lines. The arrow passing along the conduit opens the spring jacks, and the current from 6 passes in at B, goes through the motor, and out again at B on the other strip. As the car moves along to the right, 6 and 3 will close together, and the current passes along 4, through the motor to 5, and so on. The arrow is constructed somewhat longer than the distance between the spring jacks, hence it never leaves one before it enters the next one, and the metallic contact is therefore always complete. It will be seen that any number of cars can be run on the line without interfering with the electrical continuity, and the cars can follow each other as closely as desired.

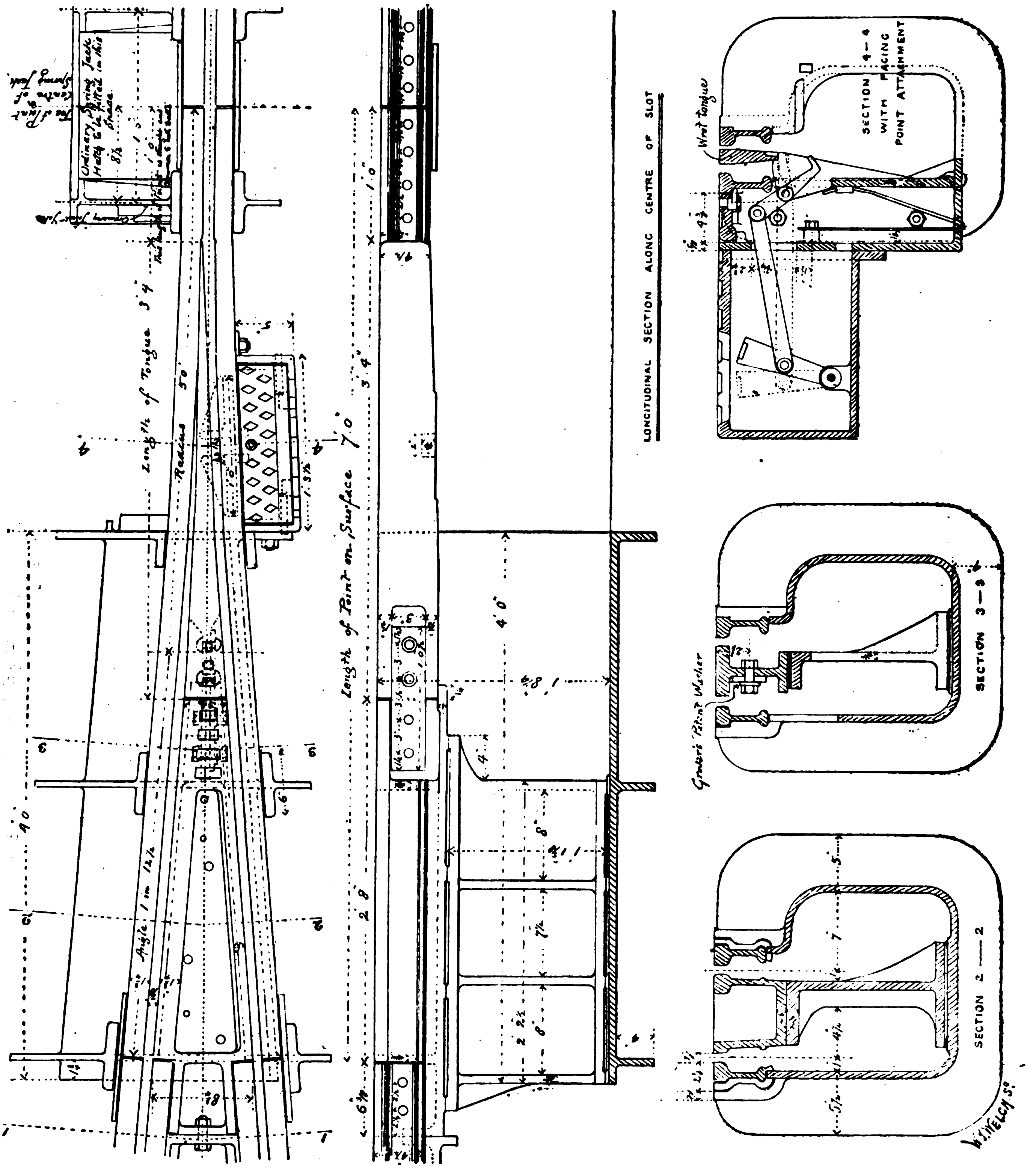


Fig. 7.—Details of the Points.

Mechanical Arrangements.

In appearance, the line has the advantage of not looking much different to an ordinary tram-line, the conduit having been arranged below one of the rails, and not, as is usually the case with cable tramways, centrally with the track. One of the rails is slotted, leaving a space of ⅞ths of an inch; through this slot the holder of the "arrow" projects downwards into the conduit. The spring jack connections are arranged to one side of this slot, so that they cannot be seen from above, and rain or slush falling through the slot cannot touch the connections. In addition, it is impossible for careless or curious persons to obtain a shock from the cable. This construction gives the least possible interference with the roadway, and the conduits are made of sufficient strength to allow for the heavy traffic of a large town, and of the smallest dimensions allowable in order to interfere as little as possible with the water or gas mains beneath the surface of the roads. In all details the

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construction of the road appears to have been carried out in a mechanical and workmanlike manner, suitable for ordinary business on town streets, and reflects great credit upon the engineers. The construction of the roadwork has been carried out to the designs of the company's engineer, Mr. Kincaid, M.I.C.E., by Messrs. Dick, Kerr, and Co., under the personal supervision of Mr. J. E. Waller, A.M.I.C.E.; the whole of the electrical details being under the direct supervision of Mr. E. Manville.

The Conduit.

The tube, as constructed at Gravesend, is 8in. in width, the bottom being 13in. below the surface of the road. The slot through which contact is made between the underground conductor and the car motor is formed by leaving a space of ⅝in. between two bull-headed rails, somewhat similar to the ordinary Vignole's railway rail, these being 4½in. in depth, with upper flanges 1¾in. wide. The outer of these rails serves as the tread for the tramway wheel, the inner corresponding to the guard-lip of an ordinary tramway rail. These rails are secured through their webs to cast-iron chairs or yokes, at intervals of about 4ft., the yokes being of such section as to leave a clear space below the bottom flange of the rail of 13in. by 8in. The walls of the conduit between the yokes are formed of Portland cement concrete 6in. thick. The rails are laid in lengths of 21ft.; the yokes on either side of the joints being placed 1ft. 5in. apart, centre to centre, and a chamber is formed where these joints occur, covered on the inner side of the rail by a small hatch, 1ft. 4½in. by 8¼in., recessed on the surface, and filled with wood-paving blocks. These chambers serve

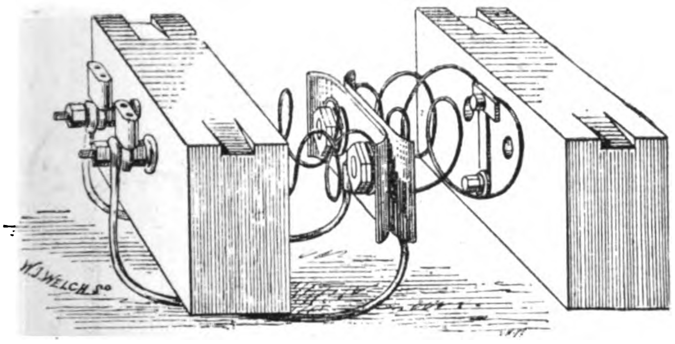

Fig. 8.—The Spring Jack.

for the purpose of access to the spring jacks, or contact points, and also admit of the removal of any dirt which may possibly accumulate in the tube, and, further, gives facility for tightening up the fishplates at the rail joints. The corresponding tramway rail is of the ordinary girder type, the gauge being maintained by means of tiebars attached to the girder rails and the cast-iron yokes, and require no further description.

Fig. 3 shows details of the construction of the line and conduit; Fig. 4 shows a section of the line through the slot; Fig. 5 is a plan showing the box, one of which is placed over each spring jack, to allow of inspection or repair.

The Line.

The line is a portion only of the Gravesend, Rosherville, and Northfleet Tramways, running from Northfleet Station to the company's depôt at Northfleet, a distance of a little over three-quarters of a mile. The line is, therefore, not a long one, and as there are only two cars needed for the working of the line, the system is not seen under its best conditions, which most favourably fit it for a long and crowded line through streets with a heavy traffic and many cars in series. The line was, however, one of the few possessing powers to run by electricity—the main portion of the line is run by horses, and goes to Gravesend, and the portion now under discussion, though short, was considered sufficient for a practical experiment of the system, and has been constructed from the first to be run by electricity. The line comprises some specimens of most of the requirements to be ordinarily dealt with on tramways. There are some pretty stiff gradients of 1 in 30 and 1 in 42; stretches of level working; a turn-out, or change over; a depot, with very sharp curve; double line; single line with crossing places; and the narrowness of one portion of the track has not even allowed of a single line down the middle, and in order to gain space for passing vehicles, a "double-single" track has been laid at this position. In this instance three rails are laid, two of them being conduit rails, and the third an ordinary girder rail, a cross-section of which is shown in Fig. 6. The car, travelling in either direction, uses the centre rail, which in one direction serves as a conduit, but in the other direction takes the place of the ordinary girder rail. At the turn-outs the junction of the conduits underneath the road necessitates the construction of somewhat special points and crossings. The points are provided with movable tongues set so as to automatically direct the traffic to the left-hand side of the road, and in order to avoid risk attendant on having a

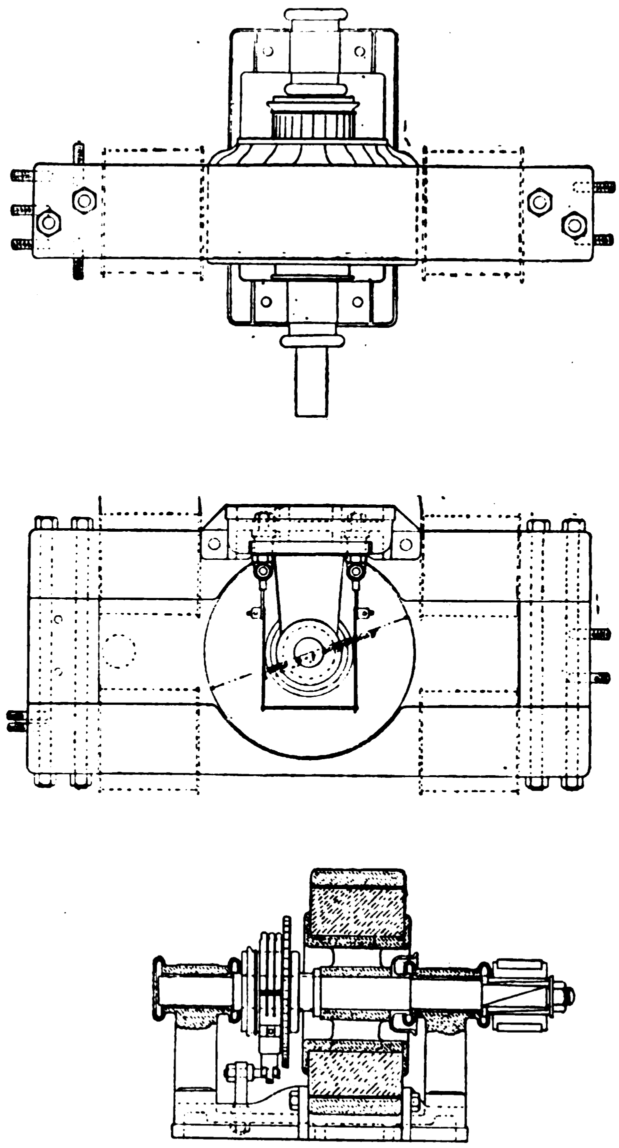

Fig. 10.—Details of the Elwell-Parker Motor used in the Series Cars.

long unsupported tongue forming the roof of the conduits at their junction, a special tumbler has been designed, so formed that it provides a support for the point of the tongue under ordinary conditions, but during the passage of a car it is deflected out of position so as to allow a full clearance for the current collector or "arrow." Where it is necessary, as, for instance, at the terminal fork at the Northfleet Station end of the line, to provide a means by which the cars can be caused to take either track, a claw is pivoted on to the tumbler which can, by means of a lever, be made to engage with the under-surface of the tongue, and thus draw it into the required position. Details of the points are shown in Fig. 7.

Along each side of the track, buried in the concrete, is an earthenware tube 3in. in diameter (*see* Fig. 7, etc.), the ends of which protrude into the cavity formed under the conduit hatches where they are open for access. Into these tubes are drawn lengths of about 21ft. of Henley's

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highly-insulated ozokerited rubber cable of an insulation resistance of 7,500 megohms per mile. An unbroken return cable is run in a line of similar tubes from the extreme end of the line, it being considered essential in this system that the earth should form no part of the circuit.

These short lengths of highly-insulated cable are the only conductors between the "spring jacks," the conduit between being only for the passage of the arrow, and therefore otherwise empty. In each conduit chamber is placed a "spring jack." These consist of a pair of glazed earthenware blocks, 14in. by 3in. by 4in., supported on brackets cast on to the joint yokes, the blocks facing each other on opposite sides of the tube. To each block is attached, by means of a double spiral spring, a gunmetal casting, curved at the ends, but flat in the centre. The springs are of sufficient strength to press the two castings together with a force of 6lb. The spring jack is shown in Fig. 8. Under the car, and for its full length, is the collector, or "arrow," which consists of two thicknesses of indiarubber belting, each having a broad brass strip riveted to it for nearly its entire length. The nose of the arrow at each end is shod with wrought iron brought to a knife edge, so as to easily force its way in between the two faces of the spring jack. The maximum thickness of the arrow is 1in., which is consequently the extent to which the gunmetal cheeks are separated. The conductor on each side of the arrow is lapped round one end, and an insulated space is left slightly greater than the surface of contact of the spring jack near the extreme ends on opposite side, as already explained in diagram, Fig. 2.

The spring jacks are arranged so that they can be taken out or replaced in the conduit in the course of a few minutes. Short-circuiting pieces are provided to enable the continuity of the circuit to be maintained should a spring jack require to be replaced without interrupting the service during the operation, the car easily running by its own momentum through the distance of 21ft., in which it would receive no current. These spring jacks are very simple pieces of apparatus of small cost, and the contact they make by their surfaces being pressed together is excellent, the resistance of the line being but very little higher than that calculated from the direct resistance of the insulated cables themselves.

The Cars.

The cars used at Northfleet were constructed by the Falcon Engine and Car Works, Loughborough, and are handsome and neat-looking cars of moderate size, without outside seats. Details of the car are shown in Fig. 9, where the gearing of the motor is indicated, and the position of the "arrow," running the length of the car on the conduit beneath the rail, is also shown.

The motors used on these cars, shown in detail in Fig. 9, are of a special type, constructed by Messrs. Elwell- Parker, Limited, Wolverhampton, and were made specially narrow to fit the cars running on a 3ft. 6in. gauge. The connection of the motor to the car is a very satisfactory one, being simple, and allowing of a certain amount of play in running. The front of the motor is supported by two bearings on the driving shaft of the car, the rear being suspended by a strong spiral spring from the car body. The motor shaft is geared directly to a spur wheel on the car wheel shaft, by double helical

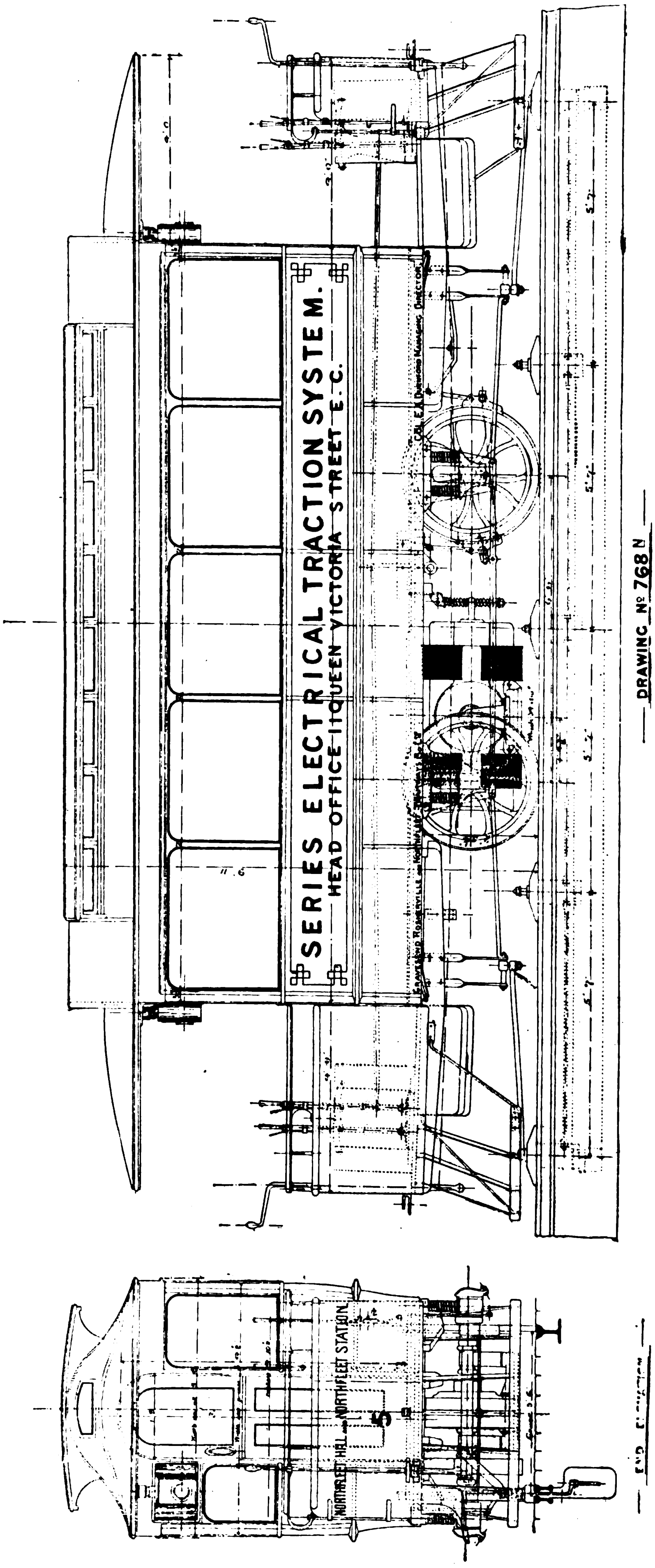

Fig. 9.—Details of the Cars of the Series Tramway.

gearing, the ratio of the wheels being one to four and a half. The motors are run at 400 revolutions per minute, delivering at this speed, when the field-magnets are fully

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excited, 15 h.p. on the brake. It will be seen that this is a comparatively large motor, running at a slow rate of speed, which, although more costly, the engineers of this line consider more satisfactory than a smaller quick-speed motor for this purpose.

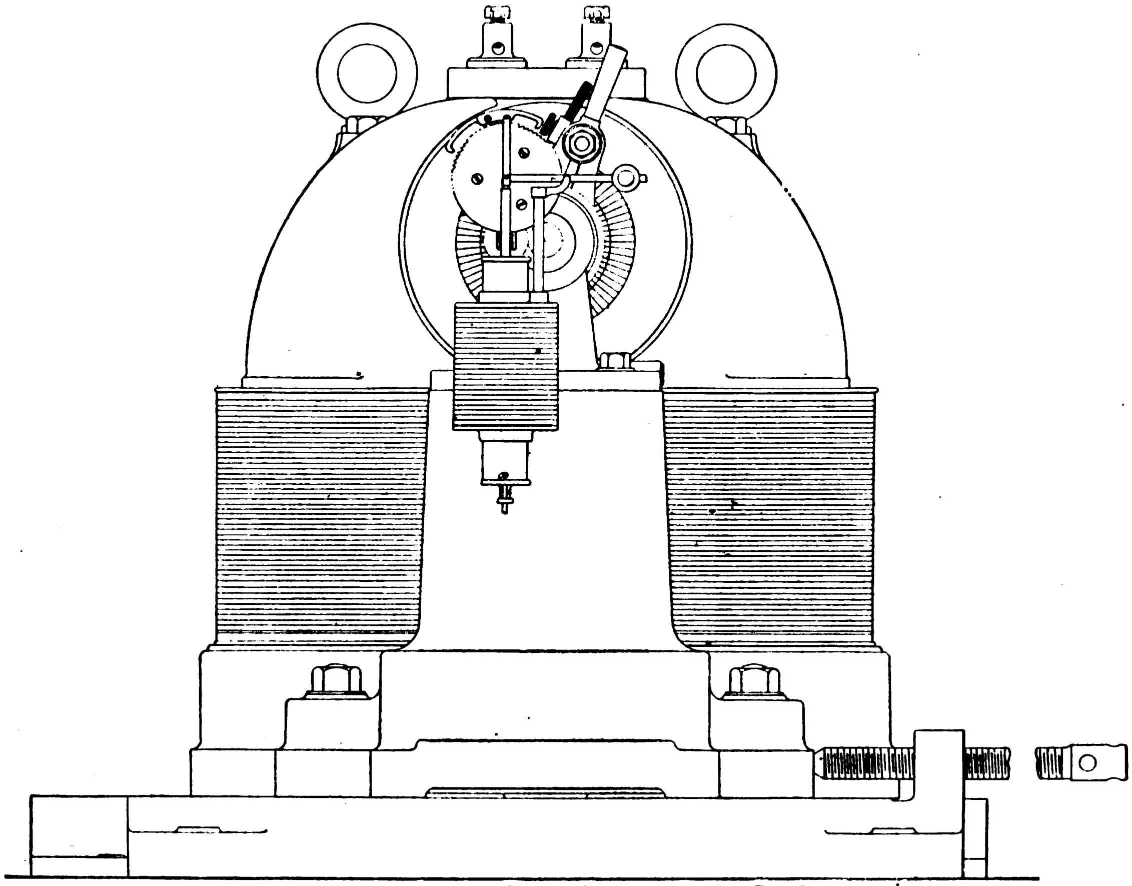

Fig. 11.—The Statter Constant Current Dynamo, showing Regulator.

The "arrow" is shown in Fig. 9 in position under one side of the car. It is supported at distances of 5ft. 7in. on cast-iron bearing blocks, sliding along the surface of the rail. These blocks are connected with iron tiebars, which

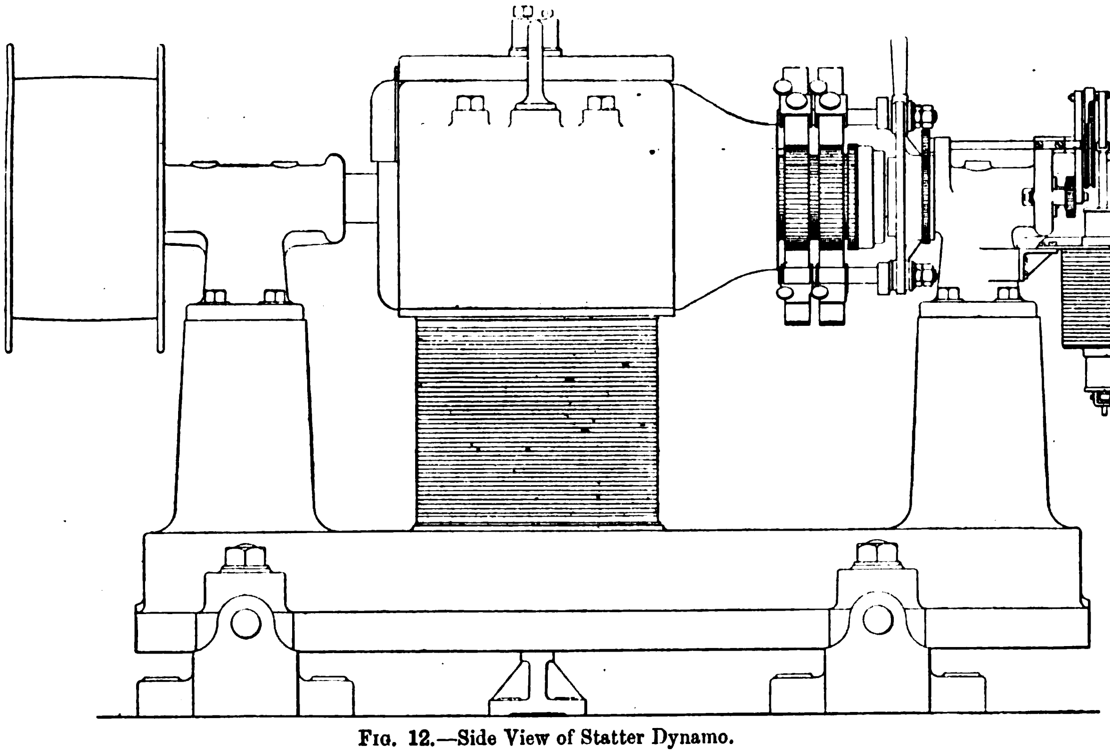

Fig. 12.—Side View of Statter Dynamo.

take all strain off the indiarubbber belt, the whole gear being propelled by the car.

The switches, for regulating the speed of the car, are arranged in strong boxes on the driver's platform, and are similar at each end. They are controlled by substantial handle levers, similar to a railway pointsman's switch, but smaller. One of these introduced a shunt into the fields of the motor of ⅓rd, ⅔rds, or short-circuits them altogether, to vary the speed of the car; the other reverses the position of the brushes, to reverse the direction of the car. The reversing of the motor in this system forms a most efficient break, the car being able to be brought to a standstill in the space of a few feet. An ordinary foot-brake is also attached. Each dynamo is fitted with an ammeter, with the point for 50 amperes—the normal current for the motors—marked in red upon its dial. One of the cars is lighted electrically by the tramway current by means of low resistance Bernstein lamps. Three E.P.S. storage cells are inserted in the circuit, and regulate the pressure to the lamps, which are run five on parallel, with the accumulators at 6·5 volts, taking 10 amperes

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each. The cells are large enough to run the lamps alone if necessary.

THE ENGINE-HOUSE AND DYNAMO.

The engine-house supplying the power for the line is situated at the depot at the Northfleet end. It consists of a small shed—one of Humphrey's corrugated iron buildings—divided into two portions, one of which is the shelter for the cars, with trench for inspection of the motor and gearing, and the other is the dynamo and engine-house. The engine is a Robey compound underneath type, of 10 h.p. nominal, with locomotive boiler over it.

For series working, it is necessary to maintain a current of constant value in the mains, varying the pressure according to the work being done and the number of cars running. For this purpose the Series Traction Syndicate have selected one of Messrs. Statter and Co.'s constant-current dynamos, a machine which they have found thoroughly satisfactory for this purpose. The Statter dynamo is illustrated in Figs. 10 and 11, the most interesting point being the method of mechanical alteration of the position of the brushes to alter the electrical pressure, and so keep the current constant. This regulation of the brushes is effected by a double ratchet working on a wheel with two sets of teeth on its periphery. The double ratchet is kept in a constant vibratory movement by the rotation of a small pinion on the dynamo shaft itself. This rocks the ratchet by means of an eccentric. The current, passing in series through a solenoid, as shown in Fig. 10, pulls down one side of the ratchet if the current tends to become too great. The toothed wheel is geared to the brushes, and on any variation of pressure in the solenoid the ratchet rapidly shifts the brushes round one way or the other, effecting an instant regulation of the pressure to the required amount, the E.M.F. being continually varied from a few volts to upwards of 400, the current remaining about 50 amperes in the mains, as shown in the ammeters of the cars when in motion. The shape of the pole-pieces of the dynamo is so constructed as to reduce the sparking consequent upon the sudden shifting of the brushes to a minimum, and although the sparking is slightly more than that of a dynamo running under fairly constant load, the sparking, when the brushes are suddenly regulated by the action of the ratchet, is remarkably small, and is, generally, barely perceptible.

The loss in the line seems somewhat heavy in this tramway, where about two miles of $\frac{7}{14}$ cable are used—being given as 140 volts when running open with 50 amperes, practically about a quarter of the whole power. The engineers have used as small a cable as possible to keep the cost of copper down, and, of course, the loss would be no more on this line whether one or 12 cars were running. If preferable, of course, a larger cable with less resistance could be used on other lines.

THE RUNNING.

The trial of the cars on Wednesday was perfectly satisfactory, and several trips were taken with the cars filled to overflowing with numerous representatives of the technical press, together with many electrical and tramway engineers. The cars started off quite easily, ran with very little noise or vibration at a speed varying up to 10 miles an hour, taking the somewhat stiff grades with apparent ease, and being stopped or reversed with admirable facility. The only possible objection that could be raised with the running was the somewhat sudden manner in which the points were taken, giving a jolt to the car. This was due to the length of the wheel base of these cars, which are halfway between the ordinary four-wheel car and the bogie cars, and could be obviated in the usual size of car. The visitors were greatly pleased at the workmanlike appearance of all the details, and the action of running cars in series—the object of this line—must be deemed satisfactorily shown.

The manner in which the details of this, the first Series line in Europe, have been carried has many important advantages.

By the use of highly-insulated cables for the greater portion of the length of the line, and where the spring jacks occur, by having but very small bare surfaces of conductor exposed to the insulating blocks, the possibilities of high insulation are obtained. The divided conductor being in very short lengths, a section of it can be renewed in a very short time without interfering with the traffic of the line. The conduit being perfectly empty, excepting at the "spring jack" chambers, is easily cleaned, and can never require taking up. Another important point is that an incipient fault in the line is easily detected and localised by the car-drivers through the readings of the ammeters on the cars, without the necessity or trouble of elaborate testing.

THE QUESTION OF COST.

It is understood that this line was completely equipped for between £6,000 and £7,000. The ordinary tram-line permanent way may be taken at, say, £7,000 per mile. The additional cost of the series conduit over this price would be about £1,500 in addition. The cost of adaptation to an existent line might be taken as costing from £2,000 to £2,500 per mile for alterations. The cost of equipping the cars with electrical motor and gearing will be a little over £200 per car with the present motors; if with quicker-speed motors they would be somewhat less on first cost. The company when formed, however, will lay themselves out for supplying and constructing series lines, in both conduit and overhead systems, or for altering existing lines at their own expense—and undertaking the running of the cars at so much per car mile, according to circumstances. They will not be absolutely bound by any particular system, but owning the fundamental patents of Fleeming Jenkin, Ayrton and Perry, and having the option of the Short-Nasmyth patents, they will seek to work the series method of traction wherever practicable as the most economical system. The estimated figures show immense saving for suitable lines over all other methods of traction, and it is believed that series tramways can be run for half the present cost of horse traction, which varies from 5d. to 8d. per car mile.

Over steam traction, where the generating motor has to be carried through the streets, the electric system shows great advantage in the saving of the wear and tear of the engines, which are rapidly knocked to pieces on the hard concrete beds necessary for steam tram-lines. Now that the system has been practically demonstrated in England, we may expect a very considerable extension on all hands of electric tramway systems.

COMPANIES' MEETINGS.

ANGLO-AMERICAN BRUSH CORPORATION.

The eighth ordinary meeting of the Anglo-American Brush Electric Light Corporation, Limited, was held on Wednesday at the Cannon-street Hotel, Lord Thurlow (chairman of the Company) presiding.

Mr. E. Garcke (secretary and manager) having read the notice convening the meeting, the minutes of the last meeting were confirmed, and the report and balance-sheet taken as read.

The **Chairman**, after referring to the balance-sheet and to the Electric Lighting Act of last session, went on to speak of the individual business of the Company as follows: We are now building—in fact, very nearly completed—a central lighting station in Chelsea. We have got a large area to supply; we have made most favourable contracts, not only with consumers, but with others manufacturing jointly with ourselves, for the plant that is required. Of course, central lighting installations and central lighting stations are still, to a certain extent, matters of novelty. A certain amount of experience has been gained, but a great deal more undoubtedly remains to be done in the way of ascertaining what is ultimately the best form of building, the best type of machinery, engines, and a thousand other matters. Well, each and all of these matters have received the most careful attention we have been able to give. At Chelsea the lighting system we have adopted is by underground mains and accumulator stations. At Bournemouth it will be by alternating underground and overhead mains, which, of course, in a comparatively rural district like Bournemouth, being more economical has very great advantages in certain cases. The distance is longer, perhaps, and the light not so continuous.

Then, I think, before I turn to the figures—about which, of course, I desire to say something—I should make some allusion, however passing and however unwillingly, to some matters before the law courts. I do not like to discuss them. Still, I think you may fairly expect, and will expect, that I should say something with reference to the pending litigation. Well, of course, the pending litigation is a very important matter. You may be quite sure it has never been absent from our minds during the past 12 months. At the same time, you must not overlook the fact that the exact character of that litigation is not so important to us as to our antagonists. What we have at stake represents one-tenth of our business; but what the Edison and Swan people have at stake represents the whole of their

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business—at any rate, as a monopoly. Therefore we can, I say, regard this matter with more calmness, perhaps, than our antagonists. It is not a matter of vital importance to us. We can go on without making lamps. We have a very large other business, which is increasing by leaps and bounds, and which, I venture to say, in the course of 18 months or two years, will surprise you all. For that reason I myself, and I think I can speak for everyone of my colleagues, regard this litigation without any anxiety—without reference to any possible result. Well, there is another reason why we can regard that litigation, I think, without overwhelming anxiety, and that is that we are confident in the justice of our cause, and we have very considerable confidence in the final issue. Of course, litigation is an unpleasant thing to be connected with, and I can only say, from my own experience, that it is a thing I am absolutely unacquainted with. I have always made terms, in any matters which have been personal to myself, with any gentlemen who have attempted in any way to get me into litigation, and I shall always pursue the same course in affairs connected with any company in which I happen to have a voice; but the present occasion is an exceptional one. We were met by people who contested the value of patents for which you had paid a very large sum—we could not act according to what might have been our desires and wishes if it had been a private matter. We took the opinion of the first counsel, and that opinion was that we had a good case, and that we ought to fight it to the utmost. We have, therefore, fought it as far as it has gone, and the result has been one thing in one Court and the other thing in the next Court, and it has been a perfect see-saw. The uncertainty of the law is proverbial, and has been certainly well exemplified in this case. You know the judgment of Justice Kay was considered at the time a very powerful decision. That went to appeal and was reversed. We have now notified our intention of taking it to the House of Lords, which is the highest court of appeal in the country. I do not know that even when we have got the decision of the House of Lords it need be absolutely final in this case, for reasons which I need not enter into; but, at any rate, we felt we had no alternative on the present occasion but to stick to our guns and take it to the House of Lords, and have accordingly intimated our intention of so doing. At the same time, as I mentioned just now, my own personal feelings are always in favour of making terms with your enemies while you are in the way—meeting them; and I think this Board has never neglected an opportunity of approaching the opposite side in the most conciliatory spirit, and with every desire to meet them half way, or as fully as I am sure any gentleman in this room would desire. I am bound to say that our antagonists have not shown the same desire, or, at any rate, the same conciliatory feeling; on the contrary, they have manifested a desire to continue this suit, and to really put us, if I may use the expression, to every inconvenience in their power. That may be all right and justifiable in a thing of this sort; and, as I said before, their position being different from ours, the lawsuit being a vital one to them, it is hardly possible for them to approach it with the same calmness and independence as we can ourselves. However, I can assure you that while we have deemed it our duty to take this matter to the House of Lords, still we are open to be approached by the Edison and Swan people at any moment. We are willing to make terms with them, so as to save your interests and to save your honour, in any reasonable way that can be suggested, and I am not without hopes that during the interval that must elapse before this case can be heard in the House of Lords, something may be done in the way of arriving at a conclusion satisfactory to both parties. Beyond that I think I need say very little on that point.

We have one other case pending at present. It is a case against King, Brown, and Co., an Edinburgh company, in reference to compound winding. You know we claim to have the control of the patents for compound winding and dynamos. That has been admitted by all English manufacturers, and they are paying us a royalty, which amounts to a very nice little income to us during a portion of these years. The only firm which has contested our rights is King, Brown, and Co., of Edinburgh. We have pursued them in the courts, and the case is still pending. Under these circumstances, I will not depart from the very proper rule, that any expression of opinion on the merits of that case is unadvisable. And now I think you will permit me to turn to the accounts, which are as satisfactory as the report; indeed, one cannot be satisfactory without the other. You will have noticed that these accounts and this report have been accompanied, in transmission to the shareholders, with a diagram, which is, perhaps, somewhat unusual; but we considered it was, perhaps, the readiest way of bringing the facts to the comprehension of the shareholders, to show to what extent the volume of business has increased, to what extent the gross profits have increased, and to what extent the general charges have, I am glad to say, decreased, or remain stationary. I think that diagram is a very remarkable paper. You see that in the five years from 1883 to 1888 the volume of business has increased from 100, which we put at par, to 307—over 200 per cent. in five years. You see that during the same period of time the gross profits have increased 254 per cent. That, I think, is very remarkable, and I think I can fairly challenge any other electric light company in the world to show similar results. And we have still one strong feature to dwell upon, and that is that the general charges have not increased—hardly at all—not only not increased in the same ratio, but, if anything, have shown a tendency to decrease. That can only be due to one thing—good management and economy, as introduced by our general manager, Mr. Garcke, in every branch of the administration. Our general charges have fallen from 100 per cent. to 65 per cent., and I challenge any other electric lighting company in the world to produce a similar and equally satisfactory diagram of their last five years' work.

Well, then, to turn to the profit and loss account for this year, you will see the gross profit of this year's transactions and trading reach the very respectable figure of £28,049. I think that is very satisfactory; and to this we have to add a balance, carried forward from last year, of £2,500, making an available balance of £30,612 to carry to general account. You will see on the other side the standing charges. I have referred to them already, generally; but I think I ought to point out that the standing charges show only an increase of 7 per cent. in themselves. The business itself has increased 50 per cent. during the last 12 months, and the standing charges have only increased by 7 per cent. Those are figures I should like you to bear in your minds. Turning to the balance-sheet, you see that the share capital has been increased by the issue of 1,160 new shares. Those shares are issued for the purpose of increasing our working capital, which, as I think you may well imagine, we had every desire to do by every legitimate means, to enable us to undertake the large contracts which are daily being placed before us, and which we are naturally loth to send away to swell the volume of business of our competitors in the trade. When I speak of our competitors in the trade I think it may be interesting to you to know that we have not had it all to ourselves, this prosperity, and this increasing prosperity, in electrical business. The Chairman stated that the number of electrical engineers in England had increased from 57 in 1883 to 260 in 1888, and said, when it was considered what the Company had done in face of this increase during the past twelve months, shareholders need not despair of the Company holding its own in the future. He then described the amounts in detail, and said: I consider that the result that has been achieved has been achieved by the continuous and united efforts—all in the same direction, enhanced efficiency combined with economy—not only of the Board here present before you, some of whom take the greatest interest and have the greatest technical knowledge of all your affairs and of everything that transpires in these manufactures, but also of your general manager (Mr. Garcke), your superintendent engineer (Mr. Raworth), your electrician (Mr. Sellon), your other electrician (Mr. Mordey), and your factory manager (Mr. Sillar). To every one of these gentlemen, in their respective offices, your thanks are due for the result which has been achieved. You stand to-day with a realised profit, available to pay, if you choose to take it, a 5 per cent. dividend on the whole of the share capital of this Company. It remains for you to decide this morning what you will do with that balance—whether you will put it in your pockets as a 5 per cent. dividend for the 12 months, or whether you will take the more prudent course, which we undoubtedly recommend, of leaving that in abeyance until litigation is over. I have no doubt in my own mind that that is the wiser course to pursue. It is the course that has been pursued by our opponents, the Edison and Swan. They had a large balance of profit on their last year's working, but did not distribute it among their members. They have held it in abeyance to meet eventualities. I think it would be unwise for us not to take the same prudent course; but if you should differ from the feeling of the Board on this point, it is undoubtedly within your competence at the present moment to elect to take that as dividend, and to divide the profit of £12,885 which stands to your credit on this year's balance-sheet.

Then I have only one thing more to say, and that is that this business is increasing, and increasing very rapidly. I consider we have overcome our difficulties of manufacture. We have undoubtedly further improvements and economies to effect. It is impossible to go on manufacturing from day to day without perceiving opportunities of manufacturing under more economical circumstances. We might follow the example of some of our friends, and take our works into the country, where labour and coal and other matters are undoubtedly considerably cheaper. Then there would be expense of moving, and other things. We may pursue that course a little later; for the present we are satisfied to remain where we are, because, while there are some of those drawbacks to which I have alluded to carrying on a manufacturing business in London, there are incidental advantages. When strangers, especially from foreign countries and the colonies—with which we do a very large business—come to London, it is a satisfaction to them to be able to see our works, to see the class of plant and machinery we have, and in some cases we supply plant and machinery to some of our colonial customers, and it is much more convenient—and I believe in many cases much more remunerative—to be able to show it to them on the ground than to take them into the provinces to see it. I feel sure that by having our works in London we get orders—and very many of them large orders—which we would not obtain if they were situated a hundred or a couple of hundred miles from London. For these reasons a move into the Midlands or elsewhere is not to be too lightly undertaken; but it is a matter we have been carefully considering, and will continue to consider, and there is no doubt that if it were done large economies would ultimately ensue. Well, what I was going to say was this—our business is increasing; it is quite necessary that our capital should increase in a corresponding manner. We have got every shilling in the business now that we are able to put into it; we have got a provision amount in it of £17,816; we have got a certain amount of that £12,885 in it, although we have nearly £10,000, as you see, at the banker's on that date (December 31). Of course, you may say we owe our creditors £22,000. It might be possible, of course, to increase that, and carry on a large business with still greater liabilities; but you know what that means—you do not get your discount on cash payments. It is necessary to avail ourselves of all these kinds of advantages. Therefore, I say that to carry on this business remuneratively in the future, and to be able to watch its growth with equanimity, and derive the greatest possible advantages from it, it will be necessary for us and for you, sooner or later, to largely increase our capital.

There is another reason why that is necessary. Look at these other companies that are doing business in the same way! Look at two or three of these lighting companies that have been recently formed in London, with their millions of capital—the London Electricity Supply Company, and one or two others that I need not mention. You know the amount of money they go to work with—a million or two millions of capital—and they have the means

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of raising that capital. Undoubtedly, if we are to compete on fair and equal terms with these other gentlemen, in course of time we must have our millions too. We have not seen this thing grow without seeing the interest that would naturally come to us if it is proved that the business is a profitable one. We have now proved the business is a profitable one—we have proved that to a greater extent than any of our competitors, and I feel confident that when the time comes, as I believe it will before very long, that we go to the public for a large increase of capital, that attempt on our part will be met by a most willing response from London and the provinces, by gentlemen who have money to invest, and take an interest in this new and increasing industry.

Gentlemen, I have nothing to add to what I have said, but I have to thank you before I sit down for the continued confidence in myself and the Board with which I have the honour to be associated. I can only say that we will continue, to the best of our abilities, to work for you, and we hope to justify the continuance of the confidence which has hitherto been extended to us, and without which I feel, for one, it would have been impossible for us to have brought this business to the satisfactory position that it now occupies. I therefore, gentlemen, beg to move: "That the report of the Directors and the statement of accounts up to December 31, 1888, now presented to the shareholders, be received, and the same be hereby adopted."

Mr. J. S. Sellon seconded the motion.

The **Chairman** answered some questions addressed to him, mentioning that the Company had successfully lighted nearly all the great exhibitions of late years, and had practically got a contract for a considerable slice of work at the Paris Exhibition.

The motion was carried unanimously.

On the motion of **Mr. Sellon**, seconded by **Mr. Copland**, Lord Thurlow and Colonel Frederick G. Steuart were re-elected directors, and Messrs. Cooper Bros. and Co. were reappointed auditors on the proposition of **Mr. Copland**, seconded by **Mr. Blessley.**

Mr. Weir moved a vote of thanks to the Chairman and other Directors for their successful pioneering of electric lighting, and also thanked the officials for their exertions.

This was seconded by **Mr. Hart** and carried, and the Chairman's acknowledgments concluded the meeting.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The Directors of this Company have declared an interim dividend of 3s. per share, or at a rate of 6 per cent. per annum, tax free, for the quarter ended December 31, payable on the 25th inst. The receipts for the week ended March 8 amounted to £5,575.

Oriental Telephone Company.—The Directors of this Company have resolved, subject to final audit of the accounts, to recommend to the shareholders a dividend of 3 per cent., free of income tax, on the paid-up capital of the Company (other than the vendors' shares) for the year ending December 31 last, placing £2,500 to reserve, and writing off the whole of the balance of the preliminary expenses—amounting to £3,000, leaving an amount of some £500 to be carried forward.

Western and Brazilian Telegraph Company, Limited.—The Directors of this Company have called a special meeting of the shareholders for the 19th inst., for the purpose of ratifying an agreement made between the Company and the Brazilian Submarine Telegraph Company, Limited, in respect of the working of the lines of the two companies and the division of the traffic receipts thereof. The traffic receipts of the Western and Brazilian Telegraph Company for the past week, after deducting the fifth of the gross earnings payable to the London Platino-Brazilian Telegraph Company, were £4,401.

Direct Spanish Telegraph Company, Limited.—This Company in their report for the half-year ended December 31st state that the accounts show a profit balance of £5,720, and that, after putting £2,500 to the reserve fund, which amounts to £13,660, there is an available balance of £3,220, out of which they recommend a dividend at the rate of 10 per cent. per annum on the preference, and one at the rate of 4 per cent. per annum, tax free, on the ordinary shares, making with the previous distribution 4½ per cent. for 1888, against 4 per cent. for 1887, £723 being brought forward towards the payment of the portion of the cost of the repairs of the Bilbao cable charged to revenue.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	18½
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
26 April	4/0	Reuter's	8	7½
......	...	Swan United	3½	8
12 July	12/0	Telegraph Construction ...	12	41
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15

PROVISIONAL PATENTS, 1889.

MARCH 5.

3808. **Improvements in electric signals for engine shafts.** James Clark Ricketson, 52, Chancery-lane, London. (Complete specification.)

3813. **Improvements in telephonic switching apparatus.** Alfred Rosling Bennett, 62, St. Vincent-street, Glasgow. (Complete specification.)

3835. **A new or improved incandescent electric lamp.** Ernst Böhm, 66, Stowe-road, Shepherd's Bush.

3836. **Improvements in electric arc lamps.** Luther Hanson, Commercial-street, Halifax.

3844. **Improvements in or relating to regulators for systems of electrical distribution.** William Phillips Thompson, 6, Lord-street, Liverpool. (The Westinghouse Electric Company, United States.)

3870. **Improvements in electric motors and dynamo-electric machines.** Henry Harris Lake, 45, Southampton-buildings, London. (Orazio Lugo, United States.) (Complete specification.)

3881. **Improvements in the method of and apparatus for regulating electric currents.** Joseph Wilhelmus Balet, 53, Chancery-lane, London. (Complete specification.)

MARCH 6.

3907. **Improvements in electrical switches.** Thomas Parker and Edmund Scott Gustave Rees, 70, Market-street, Manchester.

3922. **Improvements in the methods of suspending electric or other lights, applicable to other purposes.** Harry Christie Harold, Robert Jenkins, and Samuel Johnson, 30 and 31, St. Swithin's-lane, London.

3954. **Improvements in electric signalling systems and apparatus for railways.** Philip Middleton Justice, 55 and 56, Chancery-lane, Middlesex. (Thomas Parramore Worrall, United States.) (Complete specification.)

3967. **Improvements in arc electric lamps.** Thomas Robinson, 47, Lincoln's-inn-fields, London.

3971. **Improved compound or admixture of ingredients suitable for producing electric energy.** John James Rathbone, 166, Fleet-street, London.

MARCH 7.

3990. **Improvements in dynamo-electric machines, whether generators or motors.** William Phillips Thompson, 6, Lord-street, Liverpool. (La Compagnie Continentale Edison, France.)

4004. **Improvements in electric apparatus which may be combined with mechanical apparatus for the transmission of sound, the combined apparatus may also be applied to other useful purposes.** Robert Henelade Courtenay, 6, Anerley-street, Battersea Park-road, Surrey.

4029. **Improvements in the distribution of electric energy.** George Wilkinson, 17, Coleman-street.

MARCH 8.

4049. **Improvements relating to electric lamps.** William Frederick Smith and James Sinclair, 45, Southampton-buildings, London.

4125. **Improvements in holders for incandescence electric lamps.** Walter Osmond Rooper, 115, Cannon-street, London.

MARCH 9.

4171. **Improvements in accumulators or secondary batteries.** William Lloyd Wise, 46, Lincoln's-inn-fields, London. (F. C. Glaser, Germany.)

4192. **A new or improved regulator for transformed electric currents.** Siemens Bros. and Co., Limited, 28, Southampton buildings, Chancery-lane, London. (Alfred Mills Taylor, India.)

SPECIFICATIONS PUBLISHED.

1887.

1996. **Producing and dividing electric light.** Jablochkoff. (Fifth edition.) 8d.

1888.

2130. **Electric telegraphs.** Muirhead. 8d.

5196. **Electric rail, etc., systems.** Smith. 1s. 1d.

5452. **Protecting electric circuits.** Cunnington. 8d.

5790. **Porous surfaces for electro-metallurgic deposits.** Steinach. 6d.

6046. **Jointer for electrical conductors.** Treuenfeld. 8d.

17,223. **Secondary batteries, etc.** Paget. 8d.

17,224. **Electrically propelling vehicles.** Paget. 8d.

1889.

46. **Thermo-electric generator.** Robert and Mollison. 8d.

189. **Dynamo-electric machines.** Knight. 8d.

278. **Lightning arrester for telegraphs.** Wehr. 6d.

292. **Electric alarm thermometers.** Luck. 6d.

746. **Secondary batteries.** Lugo. 6d.

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NOTES.

Philippine Islands.—A cable is about to be established between the islands of Luzon and Visayas in the Philippine Islands.

Mexico.—Notices from Mexico state that the "Faraday" has just laid a cable between Coatzacoalcos in Mexico and Galveston in Texas.

Madrid.—At a ball recently given by the Commercial Union of Madrid, the rooms were splendidly lighted by 337 incandescent lamps.

Chelsea.—The Chelsea Vestry have assented to the proposed extension of the area of supply by the Chelsea Electric Supply Company, Limited.

Reduction of Tariff.—The Brazilian Submarine Telegraph Company notify a reduction of their tariff to Madeira, Cape Verde Islands, and South America.

Extension of Works.—Owing to increase of business Messrs. F. Wiggins and Sons have taken additional premises at 102, Minories, which is in telephonic communication with their works at 10, Tower-hill.

Underground Men.—If enterprising young electrical engineers want appointments, it would be well for some of them to specially study underground electric light cables, and how to design and superintend the laying of them. There will be plenty of demand for such men soon.

Telegraph Rates to Germany.—The *Reichsanzeiger* publishes the announcement of a reduction in the telegraphic rate between Germany and Great Britain and Ireland. In future the tariff will be 15pf. instead of as hitherto 20pf. per word. The new tariff will take effect on April 1st.

Monte Carlo.—The installation of the electric light at Monte Carlo carried out by the firm of Lombard Gerin, of Lyons, is now completed. The lighting, which comprises some 1,500 lamps, is a complete success, and considerably adds to the magnificence and physical comfort of this pleasure resort.

Registering Voltmeters.—An instrument giving a curve like a barometer register is the kind of voltmeter that should be used in electric light stations. MM. Richard Frères have introduced such a registering voltmeter in France, and the instrument is in use with great success at the central station at Pau.

Electric Lift in Paris.—The immense building at the Paris Exhibition, the Palais du Machines, for the reception of machinery in motion is to have an electric lift in one corner which will ascend to the height of about 130ft. The Compagnie Electrique, of Paris, are supplying the necessary apparatus for working this lift by an electric motor.

Spain.—An installation of electric light has been erected at Catalayud by Don José Alonso, an engineer of Sarragossa. The installation obtains its power from a waterfall by means of a turbine of 30 h.p., and comprises two Gramme dynamos, one of which is for reserve, running at 800 revolutions and 110 volts, constructed by Aboilard, of Paris.

Underground Wires.—The burying of electric wires is to be hastened in Pennsylvania by a Bill now before the Senate of that State prohibiting all suspended electric wires in cities of more than 30,000 inhabitants. The bill is intended to go into effect after August 1, 1889, and a penalty of £100 per day is prescribed for all violations of the provisions of the Bill.

Railway Rates.—The London Chamber of Commerce are agitating for alteration of the railway rates. Persons having objections to the present rates must lodge them with the Board of Trade and the railway companies not later than April 9. Members wishing to pass their objections through the Chamber of Commerce should send copies in triplicate, on forms supplied, by the 1st April at latest.

Board of Trade Enquiry.—We learn that the Board of Trade have appointed Major Marindin, C.M.G., R.E., to hold an enquiry with reference to the various applications for provisional orders and licenses under the Electric Lighting Acts which they have received in respect of the metropolis. The enquiry will be held at 8, Richmond-terrace, Whitehall, and will commence at 10.30 on Wednesday, April 3.

S.S. Oruba.—The Naval Construction and Armaments Company have this week launched from their yard at Barrow the first of two large vessels they are building for the Pacific Steam Navigation Company for the trade between Liverpool and Valparaiso. This vessel is 450ft. long, with a gross tonnage of 6,000 tons. There is accommodation for 990 passengers, and the vessel has a complete installation of electric light in every part, no less than 500 incandescent lamps having been fitted.

Electric Traction in France.—The local railway which is being constructed between Clermont-Ferrand and Royat will be run by electricity. The motive power will be produced by a 150 h.p. engine near Montferrand. The current, at a pressure of 500 volts, will be taken to the carriages by an overhead; the rails of the line will serve as the return conductor. The trains will be formed of one or two carriages, each to contain 50 persons; these carriages are being made at the works of La Buire, at Lyons.

Electric Heaters for Railways.—The Grand Trunk Railway of America is preparing to make experiments with an electric car-heating apparatus invented by Mr. Roe Fuller, an employé in the Grand Trunk shops at Portland, Me. It consists of a dynamo placed in the baggage car, power being taken from the moving axles. A metal bar is placed in a tank of water in each car. Pipes from the tanks extend all round the car. The metal bar is to be heated by an electric current, thus heating the water in the tank and pipes.

Accident Insurance.—Mr. Maynard, of the L. C. and D. Railway, Bromley, Kent, who, as agent, took so great an interest in obtaining the concession relative to accident insurance, writes to say that he will be glad to receive the names of those desirous of insuring, and to act as agent in obtaining their acceptances. If any reader experiences any difficulties in getting his proposal accepted, we are quite sure he cannot do better than correspond with Mr. Maynard, and it would not be amiss if those now insured at the higher rate were to do so likewise.

Newcastle.—Two central station schemes are on foot at Newcastle-on-Tyne. One of these, it is understood, will be run with the Parson's high-speed steam turbo-generators and dynamos. We shall be interested in seeing the application of these machines to the work of central station lighting. Some interesting details should be forthcoming before the Institution of Electrical Engineers if the Parson's generators and dynamos are set to work practically on a large scale—high speed in this case being, as is well known,

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no misnomer, a speed of from 10,000 to 18,000 revolutions per minute being obtained.

Cheap Electric Light.—We hear, on what we believe to be good authority, that a certain town council has had the offer made to it by a contractor to supply and maintain any number of arc lamps over a minimum of six for the price of £12 per arc lamp per annum. Water-power was available, and the offer was extraordinarily cheap, presumably on the chance of afterwards introducing the benefit (with profit) of house lighting to private individuals. But no—the offer was not accepted. Fourteen candle-power gas was even a little cheaper than 2,000-c.p arcs at this price, and gas it remains.

Tenders for Galway.—For lighting the harbour of Galway, Ireland, for the Galway Harbour Commissioners, the following tenders have been received:—The Galway Electric Company, 16 c.p. incandescent, £1. 19s. 6d. per annum; 25 c.p., £2. 8s.; 32 c.p., £2. 15s.; 50 c.p., £3. 10s.; 100 c.p., £5. 10s. Arc lamps, 500 c.p., £12; 1,000 do., £20 (accepted). Galway Gas Light Company, 16 candles, £2; 100 do., £7. 10s. Galway is peculiarly well supplied with water power, some 50,000 h.p. now running to waste; and it is proposed to utilise some of this power for lighting the town and harbour.

Laing, Wharton, and Down.—It has been understood for some little time past that steps were being taken to form the business of Messrs. Laing, Wharton, and Down into a limited company. We are now notified that that portion of the business relating to the Thomson-Houston system of electric lighting has been formed into a limited company, under the title of the "Laing, Wharton, and Down Construction Syndicate, Limited," with a capital of £40,000. None of the shares will, however, be offered to the public, as the whole of the issue, £30,000, has been privately subscribed.

Inserting Batteries in Cars.—To obviate the difficulties in manipulating storage batteries used in accumulator cars, Mr. John A. Brill, carbuilder, of Philadelphia, uses a method by which the batteries are easily inserted and removed from the ends of the cars. A door is made in the ends of the cars, and also a flap in the dashboard. Rollers, or wheels, are provided in the car floor below the seats, upon which are run the battery sections, properly connected, so that the whole can be run in at once and automatically connect themselves. The batteries are brought to the cars on trucks running on narrow-gauge rails, which branch off from the main track.

Removal.—The General Electric Company have removed their offices, warehouse, and showrooms from Great St. Thomas Apostle, E.C., to 71, Queen Victoria-street, E.C., a large building four houses west of the Mansion House Station. This step has been necessitated in consequence of the increase in the demand for electrical goods, due mainly to the extension made at their works in Manchester, which has resulted in the receipt of large orders for electrical fittings for the foreign as well as the home trade. This extension of business in electrical fittings and general apparatus is another sign of the rapid progress which the electrical industry has made during the last few years.

Faraday and Son's Fittings.—The great increase in the electric lighting industry of the past few months has had its influence upon the makers of artistic fittings. Messrs. Faraday and Sons have found it necessary to extend their works, and at the beginning of the new year took the lease of some adjoining premises in Berners-street, W. These are now opened in extension of their manufactory, and form an important addition to their facilities for turning out electric light fitttngs. We presume all our readers who buy fittings have possessed themselves of one of Messrs. Faraday's catalogues, which contain a large selection of very pretty and artistic pendants, brackets, and other fittings.

Electrical Engineering at Silvertown.—The extended demand for electric lighting machinery has enabled the India Rubber Company, of Silvertown, to construct a large new building for the manufacture of their Silvertown dynamos. The company have just arranged for a small private central station for 1,500 lights in the City, and it is also not unlikely that considerable work in the coming business—electric traction—will be shortly undertaken. The company are also exceedingly busy in bringing out the Weymersch battery, of which such a favourable report was issued some months ago. The battery has the very useful peculiarity, among other good qualities, of rising slightly in E.M.F. as more current is taken. Electric light cable work generally is also very brisk.

Electric Drawbridge.—An electric motor for working a drawbridge is in successful operation at Bridgeport, Connecticut, U.S. The draw weighs some 300 tons, and is attached to the bridge over the Pequonnock. It is believed that this is the first instance of this kind worked by motor. As the draw must be opened an average of twenty times daily throughout the year, the labour is great as well as expensive. The city authorities, with a view to lessen both, have introduced an electric motor of 7½ h.p., the force being transmitted from the Bridgeport electric light plant, half a mile away. This motor makes 1,600 revolutions each minute, and by the use of gearing the motion is reduced to nine revolutions, producing a power both steady and sure. The motor may be reversed, so as to turn the draw either way.

Change of Office.—The engineer's office of the Metropolitan Electric Supply Company has been removed this week from 5, Whitehall-yard to 4, Waterloo-place, S.W. The change is due to the greatly extended amount of work undertaken, and the offices are admirably suited to the purposes required. The whole house has been taken, and is handsomely and comfortably fitted. Mr. J. E. H. Gordon has a handsome private office on the second floor, with the drawing office in the room adjoining, and Mr. F. Bailey has also his office on the same floor; while Mr. Claremont, general manager, has his offices on the first floor, but the secretary's office remains at Winchester-house, Broad-street. The large advertisement of the name of the company was put up in one night to avoid damage and annoyance to the neighbours, and is now to be seen of all men passing westwards, in one of the finest situations in London.

Original Investigation by Students.—Mr. G. H. Shepardson, writing from Cornell University to the *Electrical World*, says: "Mr. J. W. Granger, instructor in the Sibley College blacksmith shop, has succeeded in *welding copper at the forge*, and has made a copper chain of $\frac{3}{16}$in. copper wire. This feat, I believe, has never been accomplished before. Several original investigations are being carried on in the laboratories. By making small changes in a Ball unipolar series dynamo, I have succeeded in getting a well-regulated *constant potential* from it. Investigations by Messrs. Nakano and Merritt have shown that of the total energy radiated by an incandescent lamp at normal

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candle power about 6 per cent. is light, while with an arc lamp only 3 to 4 per cent. is light; proving that for a given actual amount of light radiated the *incandescent lamp is more efficient than the arc.* This is contrary to common belief."

Pumpelly Storage Battery.—Mr. Pumpelly, of Chicago, has introduced a form of storage battery with horizontal plates, to obviate the difficulties due to detachment of active material and buckling. The horizontal plates—6½in. square in the standard cell—are in the form of a gridiron, and perforated to hold the largest amount of minium in a secure manner, and between each pair of plates is placed a sheet of asbestos cloth, so that if by any chance or accident any peroxide falls it is caught by the cloth, and cannot cause a short circuit. The plates have taper hubs on the ends, covered with rubber, into which the next plate fits securely, and through these is threaded a copper connecting rod, which is coated with lead to protect it from the acid. The standard cell weighs 32lb., and has a capacity of 240 ampere-hours, with an economic discharge of 25 amperes. The internal resistance in discharge is ·003 ohm.

Electric Tramway Materials.—Now that electric tramways bid fair to be the order of the day, it may be interesting to mention that Messrs. Dick, Kerr, and Co., who have just laid the permanent line at Northfleet, have recently issued an elaborate catalogue and descriptive list, plentifully illustrated and well bound, under the title "Tramway Materials." In this, we find some 40 sections of tramway rails, in full size, as kept in stock; illustrations of tramway points, wheels and carriages generally. Besides this, there are a number of interesting views from photographs, showing various tramways in course of formation, with views of power stations—in this case for cable machinery—soon, we hope, for electric machinery only; and steam locomotives, which will soon also make way everywhere for the electric engine. Tramways themselves, however, will continue to increase, and those who have anything to do with the construction of them should obtain a copy of Messrs. Dick, Kerr, and Co.'s book.

Storage Cars in Washington.—The Main electric car, controlled by the River and Rail Electric Company, of New York, has recently, says the American *Engineering News*, had a successful test in Washington, and is said to promise excellent service. The system uses only one motor instead of two, and the entire motive apparatus, storage batteries and all, weighs only some 4,000lb., it is stated, being much less than most other motors. The speed of the car was eight to twelve miles per hour. The mechanical connection between the motor and the sprocket-wheel driving-chains is exceedingly ingenious, novel, and compact. The motor is not stopped because the car is stopped, but continues in motion unless the stop is to be of some duration, and a change can also be made from high speed and low power to low speed and high power without any change in the motion of the motor. The storage batteries, likewise, are claimed to be a great advance on past practice, especially in respect to durability.

Suggested Electric Lighting for Dorchester.—An application was recently made to the Dorchester Gas Company by the Town Council for a reduction in the charge for the public lighting. The directors, in reply, reminded the Council that the terms of the contract of 1887 were approved of by the Corporation, and as the cost of producing gas is the same now as it was then, they could not see their way to making any alteration in the price. At the last meeting of the Town Council, Mr. George said he thought the company were pressing the Corporation very hard, because there was now in London a company who were willing to supply the electric light at a rate equivalent to 4s. per 1,000ft. of gas, and in Dorchester they were well situated for electric lighting, because water-power could be utilised. If the gas company pressed them too hard, it would be worth while to consider whether it would not be cheaper to introduce the electric light in Dorchester. After further discussion, it was resolved to apply to the electric light company in question to furnish an estimate for the supply of the light.

Electricity from Solar Energy.—Prof. Thornton Osmond, in America, has been making experiments with the idea of obtaining electric energy direct from the source of all terrestrial energy, solar heat. Should not, he asks, the rotation of the plane of polarisation produce magnetism? With a view of testing this, he constructed a polariser of thin sheets of glass, set in a tube at an angle of 35° 25' with the axis, to give a transmitted polarised beam 5 centimetres diameter. This tube was rotated and a beam of sunlight sent through it from a heliostat. Three coils from 18 to 63 centimetres long, wound with wire and fitted with soft iron tubular cores with glass ends, were filled with various gases, liquids, etc., to be traversed by the beam, whose plane of polarisation was being rotated. Several experiments were tried with an astatic needle placed in the rotating beam, and in two or three of the experiments there were traces of electric action. Prof. Osmond is intending to repeat these experiments at the Pennsylvania State College, and continue the research by other experiments with new apparatus. The details given are incomplete, but suggestive, and may lead to further results.

Catalogue of Electric Bells.—The seventh edition of the General Electric Co.'s Catalogue of Electric Bells has just been published. It is a book of some 50 pages, similar to their catalogue of electric light fittings lately noticed in these columns, and comprises practically every requisite that can be asked for in the working of electric bells. We see details of connections, with explanatory diagrams, for fitting up; illustrations of trembling bells and continuous bells; circular and bracket bells; bells with indicators; bells with pendulums; and bells with varied chimes. Indicators of all types and sizes are also shown, and electric bell sets with self-contained battery to suit all requirements. Pushes and door-pulls are shown in great variety to suit the decoration of houses, and switches, wires, batteries, screws, and fittings are all illustrated, besides alarms, galvanometers, lightning conductors, telephones, telegraphic instruments, and electro-medical appliances. The catalogue contains some 260 illustrations, and should prove exceedingly useful for the purchase of electric bell fittings in England and the colonies. Those of our readers who deal in this class of work should not fail to apply for a copy.

Law Courts Branch Bank.—It speaks well for the progress of electric lighting, when carefully installed, that the Bank of England after making very considerable tests have not only extended the light very largely throughout the Bank itself, but have authorised its introduction throughout the whole of the fine block of buildings which has recently been erected at the Law Courts. Messrs.

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Drake and Gorham have now completed this work, which is giving every satisfaction, and the benefit of the light is already fully appreciated. The plant consists of a Crossley gas engine driving a 12-unit Elwell-Parker dynamo, which supplies current to 53 large D. and G. cells, manufactured by Elwell-Parker, Limited, and the total number of lamps fitted exceeds 200. Great care has been taken in dividing off the different portions of the plant, so that the exhaust pit, circulating tanks, and other sources of heat are completely separated from the engine and dynamo room, a very necessary precaution where ventilation is difficult. The current is distributed by one of Drake and Gorham's ring contact switchboards, which arranges for the regulation of both charging and discharging circuits and the measurement of the current in both dynamo and lamp circuits with one ammeter.

Electric Lighting in Algeria.—The central station recently opened at Milianah, Algeria, is an extremely interesting one. It has two Manchester dynamos driven by a Meunier turbine, and giving together 210 amperes at 110 volts. The station is established in a mill just outside the town; the main cable, 100 millimetres square in section, is about 550 yards long in one direction, and the distribution is effected to twice this distance. The public lighting at present consists of 40 lamps of 20 candles, 25 lamps of 50 candles, and several of 200, 300 and 500 candles at the principal crossings. All the town buildings are also lighted electrically. The installation was carried out by the firm of Feray, of Essonnes, at the cost of about £2,300. The maintenance, including depreciation and interest, is given at about £330 per annum, and the income from private customers is already £310 per annum. The public lighting, therefore, does not cost more than £20 a year, while the public lighting by oil had hitherto been almost £250 a year, besides not giving anything like the amount of light. The price of 20-c.p. incandescent lamps to private customers is 30s. a lamp a year. The success of the installation from the financial point of view is extremely satisfactory, and represents an example that might be largely imitated.

London County Council.—At the last meeting of the London County Council on Tuesday, held at the Council Chamber of the Guildhall, Mr. Beal moved: "That it be referred to the Finance Committee to consider the steps to be taken, if they so advise, as to acquiring the undertakings now supplying London with water and gas: as to the former, whether new sources of supply should be reported on by the engineers of the Council, and, if so, what time would be required for that purpose, having in view the report of several Royal Commissions; and, as to the latter, the recommendations essential as to the competition of electric supply; such report to be presented not later than June next, in order to permit the requisite notices to be considered, prepared, and given in November for the ensuing session, and that the requisite powers may be obtained by any Bill promoted this session by the Council." Mr. Æneas Smith seconded the motion. Capt. James moved as an amendment, "That in the opinion of this Council it is inexpedient to take into consideration the motion until sufficient time has elapsed for the Council to have thoroughly mastered the duties at present conferred on it." The amendment was negatived by a show of hands without discussion. Mr. Rhodes suggested that the question of gas should be omitted from the motion, and this Mr. Beal agreed to. After some discussion, the matter was referred to a special committee.

Telephonic Communication in Paris.—The Paris correspondent of the *Daily News* says: The Municipal Council has been discussing various proposals for improving telephone communication in Paris. The concession of the present company lapses on September 8, and whether it is renewed or not, the rates will be lowered and faster communication secured. At present the subscription in Paris is excessive, about £24 a year, whereas at Brussels it is only £10, and at Boston and Philadelphia £5. Paris has a smaller proportion of persons using telephones than most cities, except, I believe, London. The proportion here is about 1 to every 400 inhabitants; while in New York it is 1 to every 90. The complaints about the service in Paris have at length had some effect, the company having spent over £8,000 last month on improvements, on the chance of obtaining the renewal of its concession. Paris, however, is tired of monopolies, and the Corporation will not lose an opportunity of abolishing one. Among the most ingenious proposals is that of M. Leon Donnat, the municipal councillor and a leading economist, who would give the lease of the telephone system to the subscribers themselves, incorporated as a co-operative society. The rate would be reduced to £16 a year at the utmost, and in addition to this subscribers would benefit as part proprietors, while the city might gain by the increased exchanges.

The Continental Submarine Cables.—A news agency states that the representatives of the French and Belgian Telegraphs Department who were deputed by their respective Governments to discuss with the English officials the terms upon which the submarine cables between England and those countries should be taken over, have arrived at an agreement as to the price which shall be offered for the cables and plant. This was promptly communicated to the British Treasury, where the agreement arrived at was definitely approved, and an offer was immediately afterwards made to the Submarine Telegraph Company on behalf of the countries interested. The price which the three countries have agreed to pay is not so large as the directors of the Submarine Telegraph Company expected, but, on the other hand, it is far from being a confiscation price, which many of the shareholders anticipated. The amount will be announced in Parliament within a few days, immediately after the French and Belgian Governments have ratified the decision arrived at by their representatives. There is now not the slightest doubt that this will be done, and that the General Post Office will be in a position to take over the working of the submarine cables on the 1st April. The officials of the English Post Office are to be congratulated upon the skill which they have displayed in bringing this most difficult business to a successful issue.

Electric Central Station in New Zealand.—A proposal is on foot at Dunedin, Otago, New Zealand, for the formation of an electric power company to run the tramcars of that city, and to supply light and power to the neighbouring shops and houses. The comparative running expenses per mile on the different systems of traction were estimated by Mr. E. J. Foord, as follows: By horse, £1,936; by electric conduit, £1,006; by electric overhead, £665; by cable, £1,698. The proposed central station, site, buildings, boilers, and fittings were estimated at £15,165. This would provide for one car to carry 70 passengers, one to carry 32, and the 17 cars at present belonging to the tramway company, converted into cars electrically driven—making 19 cars available. It was also proposed to drive them four miles an hour faster than they

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were at present, thus virtually increasing the plant by one-third. The expenses of working the trams by electricity would be £4,865, after making a liberal allowance in all cases. A saving was reckoned on of 2d. per mile, being equal to £2,750 per year. The revenue under the proposed system was estimated at £6,675. An alternative proposal was for a generating station at Green Island, where coal and water would be cheaper; and, further, 150 h.p. could be supplied to users at a profit. A committee was appointed to endeavour to carry the matter out, and obtain estimates. It is pleasing to us to see the English colonies are at last beginning to take up the question of electric traction practically, and we hope the proposed station in Dunedin will shortly become an accomplished fact.

The Metropolitan Electric Stations.—The work of dotting the vast area of London with 20,000 light stations, undertaken by the Metropolitan Electric Supply Company, is proceeding apace. They have now five or six stations either begun or actually contemplated. These stations will be on the alternating current transformer system, and each will have trunk lines connecting it to two other stations, so that even in event of total breakdown in any one station, the district would not suffer darkness. The only station which will not be so connected is the first, Whitehall Court, which is more or less a local and restricted supply station for Whitehall-mansions and a few neighbouring buildings. St. Martin's Church is lighted from this station, and also Messrs. Hampton's, in Pall-mall, besides the Avenue Theatre; and the Hotel Metropole and the Grand Hotel will be connected shortly, making a total of about 5,000 lamps, which is as much as this station will supply. This is on the low-tension direct current system, with accumulators. Number two (the first alternating station) will be Sardinia-street, Lincoln's-inn-fields, where building is now going on night and day, the wall rising at some 5ft. a day. The Westinghouse Company have the electric part of this station—which is for 25,000 lamps—entirely in their own hands. It will be a show plant, and they may be depended upon to do their best. The machinery is now nearly all in London, and ready to fix. The chimney shaft is some 12ft. square. The boilers, Babcock and Wilcox type (also ready) are to be placed below ground level, and the steam will be delivered upward to secure dry steam. The engine-house is in two storeys, lined with white bricks—Westinghouse engines on the ground floor, driving Westinghouse dynamos by belting on the floor above. Space is allowed for doubling the station, which will supply the central district from Holborn to Ludgate-hill and Fleet-street. The mains will be underground as far as possible. The third station is that known as Pritchetts, Rathbone-place, which has been bought as a going concern of 2,000 lights, Mr. Pritchett having accepted the position of managing engineer of the station. The Mordey alternators will be taken out and replaced by six 2,000-light alternating machines, made by Elwell-Parker, and driven by Willans engines. This plant is ready, and was, we believe, originally made for the House-to-House Company for sending to Australia, and has been bought up by the Metropolitan Company to equip this station at once. It is promised to be running by the end of May. The fourth station, Kapp dynamos made by Johnson and Phillips, is the Waterloo-wharf Station, not yet begun, although the machinery is in hand. The fifth is for Manchester-square, to supply the Duke-street and Marylebone district. Another station is also in contemplation for the Charing Cross district, for which drawings are completed, but the site is not yet settled. The work thus undertaken has meant the expenditure of £400,000, and the whole of these stations, it is expected, will be at work this year. Orders have been booked up to the present time for some 90,000 lamps.

Thomson-Houston System at Reading.—The electric light made its first appearance, by way of street lighting, in Reading, just after midnight on Friday, and the public opening took place on Saturday evening last, when thousands of people had congregated in the main thoroughfares to witness the demonstration. The installation has been carried out by Messrs. Laing, Wharton, and Down, who are under an agreement with the Corporation to light, by way of experiment and at the proposal of the firm, some of the principal thoroughfares for a month, the local authority undertaking to provide the poles to carry the wires and the lamps, and Messrs. Laing and Co. the current lamps, wire, and all other necessaries free of charge. The selection of the sites of the lamps was left to the Corporation. The depot at Reading is situate on what is known as the Island, in Duke-street, and the plant laid down consists of two 10 h.p. nominal engines, running at 380 revolutions, with steam at 110lb. These drive two Thomson-Houston H type dynamos, with 950 revolutions, and capable of supplying 18 1,200-c.p. arc lamps on a five mile circuit. The plant has been supplied in duplicate throughout, so as to prevent an extinction of the light in case of a breakdown, and a few seconds only are required to change the lamp circuit from one dynamo to the other. The switchboard allows one or other dynamo being connected to or taken off the lamp circuit whilst the lamps are alight. The boiler is one of the Babcock and Wilcox 25 h.p. water tubulars, which has amongst its principal advantages the continual circulation of water, the small consumption of coal, and the great rapidity with which steam can be got up—110lb. pressure can be obtained in 30 minutes. The boiler is fitted with a Worthington feed pump and a water purifier of improved construction. There are at present six arc lamps in the public streets, and two others for private users. Those in the streets are Thomson-Rice pattern, and the others are Thomson-Houston lamps, the latter being more suitable for indoor use. The carbons are Lacombe and Co.'s best cored, 12 millimetres, burning about 10 hours without trimming. The insulators are of Johnson and Phillips' fluid type, guaranteed to give higher insulation than those of any other make. The installation, at the opening on Saturday, suffered a little on account of the brightness of the night and the rising of the full moon. The lamps also were rather too high on the poles, and the opal glass globes did not allow of a full light. These drawbacks have since been remedied by the local manager, Mr. F. F. Yeatman. Now that the nights are darker the light shows brilliantly. The single lamp at present in the large space in front of the Municipal Buildings is not sufficient, and two or three will probably be required. The light is beautifully clear and steady, and is free from hissing. It is stated that 30 1,200-c.p. arc lamps would light the central part of the borough at a cost per lamp of about £22 a year. In other words, for an increased outlay of about one-third the present cost of lighting, ten times as much light would be guaranteed. The cost of the private lamps is £15 a year, inclusive of everything except £1 for fixing.

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THE VICTOR TURBINE.

Now that the transmission of power by means of high-tension currents for considerable distances is a problem which electrical engineering has little difficulty or hesitation in undertaking, the question of a good and economical waterwheel becomes a point of just importance where advantage can be taken of natural sources of power. In France, in Germany, and in Switzerland examples are now not at all rare of small towns, or even fairly large ones, being lighted up with both arc and incandescent lights in their public streets, and with a supply of current for several hundreds or thousands of incandescent lights for private houses, the power being obtained from

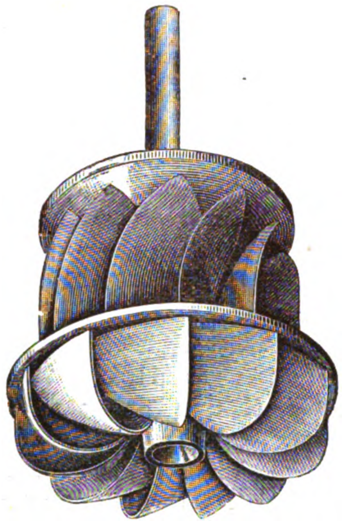

Fig. 1. Victor Turbine Removed from its Case.

a fall of water, sometimes at distances of some miles from the point of distribution. Without arguing that England in this respect should be as well off as other countries in instances of this kind, there are, without doubt, many places where the water-power now running to waste could be made, by means of high-tension

of turbine, in that it receives the water upon the outside, and discharges it downwards and outwards (in the vertical form of turbine), the lines of discharge occupying the whole

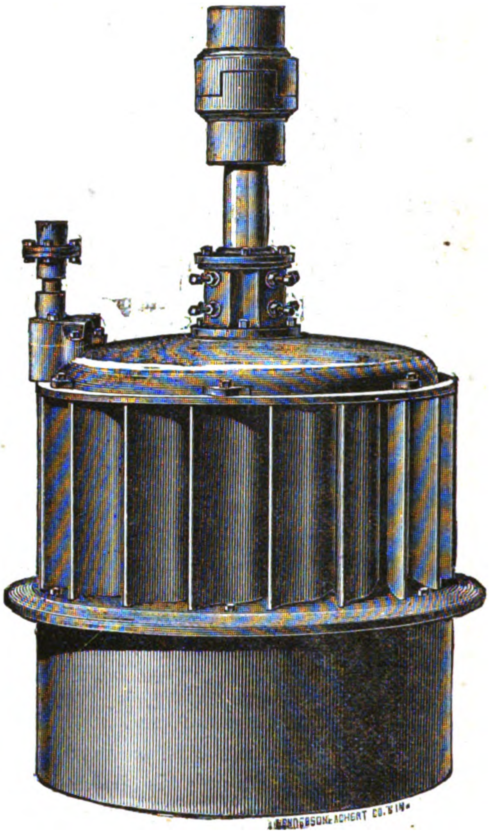

Fig. 2. Victor Turbine and Case complete.

diameter of the lower portion, with the exception of the shaft itself (see Fig. 1). This construction gives a maximum capacity for a given diameter, and the tests which have been made officially in competition with other makes in America showed some very remarkable results. The 15in. Victor turbine, under 18·34ft. head, actually gave

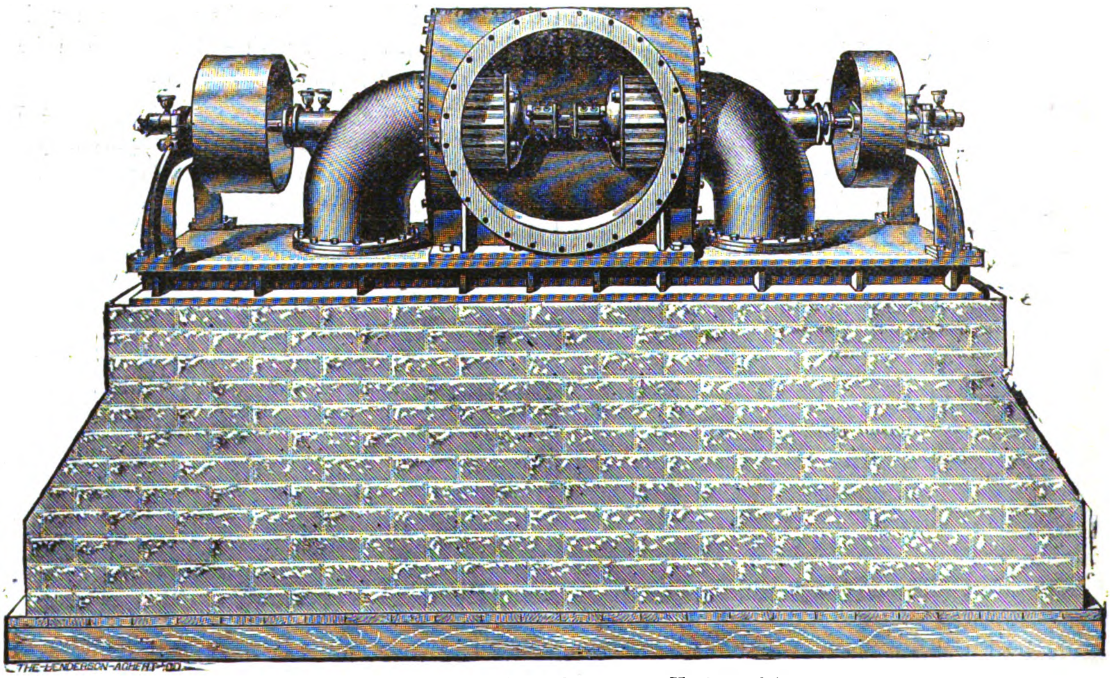

Fig. 3. Pair of 12in. Victor Turbines on Horizontal Shaft.

transmission, to supply light and power to neighbouring districts with economy.

For the development of water power the Victor turbine has proved itself satisfactory in all parts of the world, giving a very high return of the theoretical power available, and we illustrate herewith some examples of its appearance and application in actual work. The Victor turbine is different in construction from most forms

29·36 h.p., at an efficiency of 88·08 per cent. This size of turbine by other makers is tabled to give from 8 to 15 h.p., and the saving both in outlay and in carriage with the more capable wheel can be easily realised. The efficiency, also, is extremely high, very few turbines being able to reach much over 70 per cent. efficiency, while the official tests of the Victor turbine show efficiencies of 89·60 per cent. for the best test

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of a $17\frac{1}{2}$in. wheel, and 82·89 per cent. for the lowest efficiency of a 35in. wheel. Proportionately high results were obtained at partial gate with the various sizes.

In construction, all parts of the Victor turbine are bored and turned by machinery, every part being fitted to standard

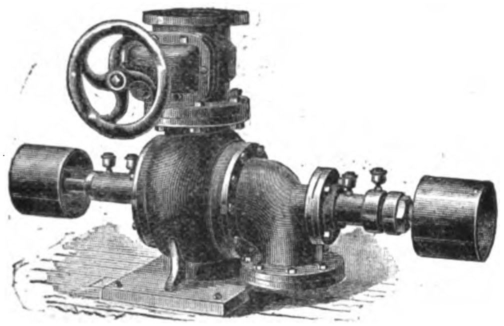

FIG. 4. 5in. Victor Turbine for High Falls.

gauge, and duplicate parts can be furnished in case of accident. The fitting together is simple, and facilities are provided for taking up the wear without removal. Provision is also made for perfect lubrication.

on horizontal shaft, with flume fitted in one piece, as shown in Fig 4. The wheel in this case is made of gunmetal, and the discharge and supply pipes are both of 5in. diameter.

One of the recent applications of these turbines is that shown in our last illustration, which represents the power-house of the Clifton Manufacturing Company, Clifton, South Carolina. A portion of the wheelhouse is broken away to show the waterwheel plant, consisting of two pairs of 48-in. Victor turbines on horizontal shaft, working under an 18ft. head, and capable of developing 980 h.p. This plant drives the whole of the machinery of the factory, and also supplies light for the adjacent buildings by means of dynamos.

For regulation, the turbine is fitted with a register-gate, which is moved by a segment and pinion, or can be controlled by a governor. The movement of this register-gate regulates the amount of water supply without changing the direction of the current or the relative angle of the stream with the blades, and without in any degree checking the velocity of the water admitted.

Mr. Frederic Nell, of 16, Mark-lane, London, for whom these turbines are built, has issued tables from which the water-power of various falls can be calculated ; and in order to effectually fulfil stipulated requirements, will agree to specify in the contracts undertaken the actual horse-power delivered under given head with stated quantity of water, and will also advise or superintend the installation of water-power installations.

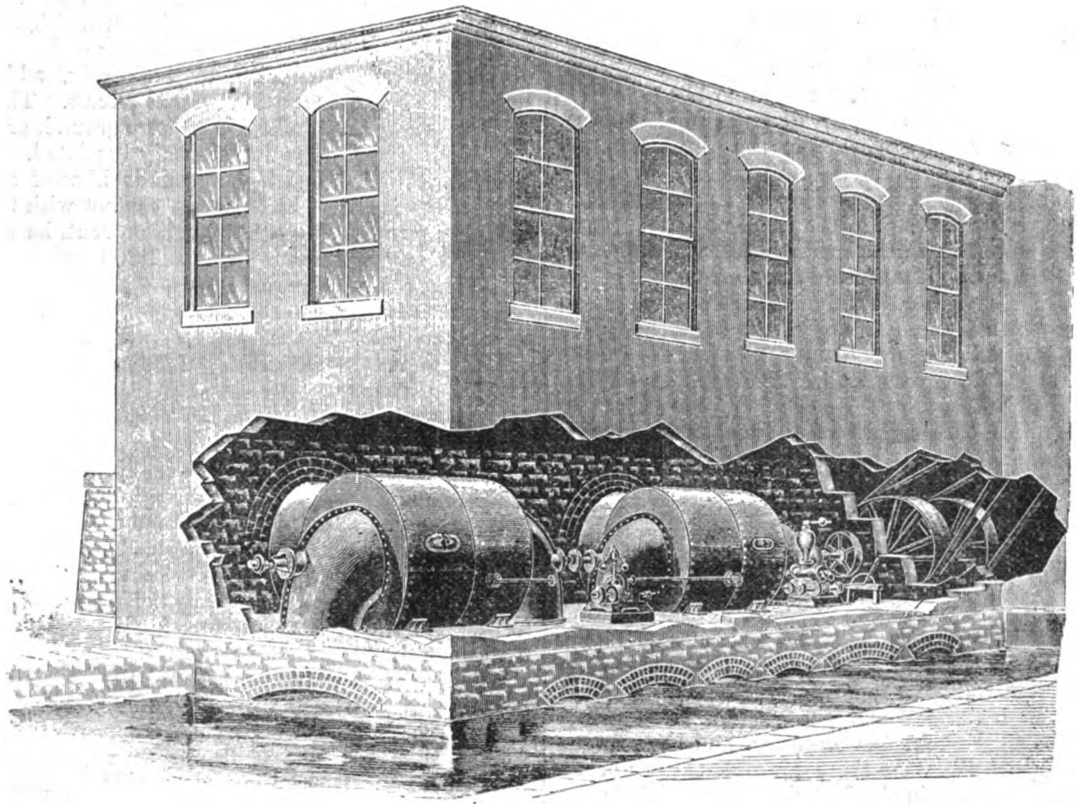

FIG. 5. Victor Turbines, 980 h.p., at Clifton, South Carolina, U.S.

The appearance of the Victor turbine in its case complete, as sent out ready to set in the flume, is shown in the illustration, Fig. 2. The water is received above from the outside, and is discharged inside the bottom casing, rotating the shaft at a high rate of speed. The shaft can be directly connected to gearing, or be furnished with clutch, as shown.

For electric lighting it is often more suitable to take the power from the shaft of the turbine by means of pulleys and belts direct to the dynamos, and for such cases a horizontal form of turbine is constructed. In many instances a pair of horizontal turbines are connected together on one shaft, and served from one water flume. This arrangement is shown in Fig. 3, which illustrates a pair of 12in. turbines, with bearings and pulleys complete, on foundation, constructed to operate under 46ft. head. This pair of wheels was constructed for an electric light company, and a similar arrangement has been furnished to drive the huge dynamos of the Cowles Electric Smelting and Aluminum Company, where a pair of 30in. turbines, under 35ft. head, furnish 528 h.p. with great satisfaction.

For special circumstances where a high fall and small quantity of water is available, a 5in. turbine is constructed

ELECTRIC LIGHTING OF THEATRES.—V.

ADELPHI THEATRE.

This theatre possesses a very fine and most complete installation of the electric light. The front of the house, auditorium, stage, dressing-rooms, etc., are all lighted electrically, and there is not a single gas-jet in the building. Danger from fire is not only guarded against by banishing gas, but also by laying the electric light leads on an incombustible principle. Virtue is sometimes its own and sole reward; but in this case Messrs. Gatti's prudence is rewarded by a very substantial diminution in the insurance rate as well. The Adelphi Theatre, Adelphi Restaurant, and the Adelaide Gallery Restaurant, of Messrs. Gatti, are all lighted from a little station of their own in Bull-

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inn-court. This station has a lighting capacity of 5,000 incandescent lamps of 16 c.p. each; and, as Messrs. Gatti only require light equivalent to about 3,200 16-c.p. lamps themselves, they contemplate doing some lighting in other buildings in the neighbourhood, and already light the Peacock Inn with about 100 lamps.

Their station is fitted throughout with most excellent machines and accessories, and is very well arranged for easy management. The plant consists of three boilers of the well-known Babcock and Wilcox type, each of 156 h.p.; two large and one small centrifugal steam separators, with Tangye's feed-water pumps, and also an exhaust steam injector. The engines are by Willans and Robinson—two of 130 h.p. each, and two of 75 h.p. each. Four dynamos of the Edison-Hopkinson type (shunt-wound machines) are driven direct by the Willans engines; the two larger dynamos give a maximum current of 800 amperes each at 425 revolutions per minute, and the two smaller a maximum current of 475 amperes each at 450 revolutions per minute. Each of the dynamos has a small flywheel to ensure the absolute steadiness of the lights. One large and one small engine and dynamo do the lighting, and the remaining two are spare sets in case of accident. The voltmeters employed in the engine-room are of the Schuckert type, and the resistances are of iron wire spirals. The leads from the four dynamos are taken to two large switchboards, which are arranged very much after the fashion of a telephone exchange switchboard. By the one switchboard the whole load of a dynamo and its engine can be transferred to its fellow dynamo and engine, and by the other any part of the load can be transferred from any dynamo to any other. When a dynamo is going to be put on in place of its fellow, it is brought up on resistance to give the required current, and then plugs are so put in on the switchboard that the turning of a handle transfers the fresh dynamo from the resistance to the lamps, and the other dynamo from the lamps to the resistance, so that there is no interruption (nor even flickering, as we had the opportunity to observe) of the lighting. From these two switchboards the cables are led to the theatre switchboard at the side of the stage, and to the two restaurants. The whole of the theatre lighting is controlled from the stage switchboard. The cables are of the best quality throughout, and very great precautions have been taken with the whole of the wiring. The copper is first well insulated in the ordinary way, and then coated with asbestos. The asbestos-covered leads are drawn into iron pipes of the required sizes, and then laid in wood casing as usual.

The front of the house is lighted by about 250 16-c.p. lamps, arranged for the most part singly. The auditorium is lighted by eight Sunbeam lamps of 200 c.p. each, which are arranged in a circle round the dome. These give a very good light throughout the auditory, and have a very pleasing effect. On the stage there are four battens of 85 white lights in each, and in the float three rows of 60 lamps in each row. The first row consists of white lights, the second of red, and the third of blue, so that the sunset and moonlight effects are produced without mediums. In the dressing-rooms there are 105 16-c.p. lamps, and in the basement 68 16-c.p. lamps.

The possibility of being able to completely extinguish the lights on the stage and in the auditorium is employed in this theatre for the changing of scenes without the lowering of the curtain. Thus, when a very great change is not required, these lights are turned off, the scene changes, and the lights are turned on again.

The management of this theatre experience all the advantages we have enumerated in previous articles as consequent on the substitution of electric for gas lighting; but we may mention that in their case the reduction in the insurance rate is very great—viz., from £2. 2s. to £1. 5s. per £1,000, or about 40 per cent. diminution. The relative cost, taking account of the interest on the capital sunk, depreciation, repairs, etc., they find to be slightly greater than with gas, but as set-off to this they have more light, and no doubt when their plant is worked to something near its real capacity they will find the balance of cost the other way. Out of every three lamps together, two are on the circuit of one dynamo, and the third on that of the other running dynamo, so that there is no possibility of any part of the building being plunged into total darkness by any breakdown of an engine or dynamo, etc. We may conclude by repeating that the general installation, plant, and fittings are all excellent, and on a very good—carefully designed and well carried out—system, which reflects the greatest credit on all concerned with it.

The whole of the works have been carried out under the superintendence of Mr. Spencer Chadwick, architect, of 17, Parliament-street, Westminster.

STANDARD OF INSULATION FOR ELECTRIC LIGHT CIRCUITS.

BY G. E. FISH.

In establishing a standard insulation for electric light circuits three questions are to be considered. The first and most important is to guard against danger to human life; second, to guard against fire; and third, the cost of maintaining this standard. Ohm's law shows that the quantity of electricity passing through a conductor is equal in amperes to the E.M.F. in volts divided by the resistance of the conductor in ohms. If a man comes in contact with the conductor of an arc or incandescent circuit, a current will pass through him which will be equal to the E.M.F. of the current passing through the conductor divided by the resistance of his body, added to the resistance of the insulation of the circuit. This assumes that the man is standing on damp ground, or is in some position in which he is not perfectly insulated. If one terminal is grounded, and if he grounds himself at the other terminal at the time he comes in contact with the conductor, which is carrying a 1,000-volt current, he will receive in his body current equal to 1,000 volts, divided by 5,000 ohms or ·2 ampere.

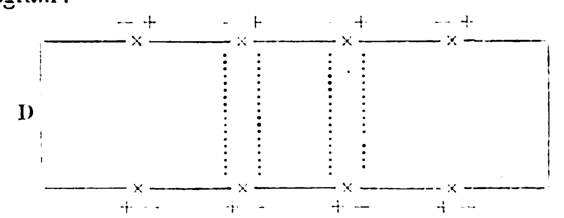
I have measured the resistance of several men from hand to hand, and find that they average from 4,000 to 15,000 ohms. As it is a generally accepted fact that 1,000 volts will kill a man, and assuming from the above test that the average resistance of the human body is 5,000 ohms, we get by Ohm's law $\frac{1,000}{5,000} = \cdot 2$ ampere, which would go to show that the quantity of current that will destroy human life is two-tenths of an ampere.

A gentleman who is well informed in electrical science claims that one-tenth of an ampere is all that is required but I once had an opportunity of disproving the statement. An employé was connecting a testing device to be used on a dynamo that at the time was running with 32 arc lights. The potential had been taken a few moments before, and was found to be 1,300 volts. The device was to be shunted across the terminals of the dynamo. At the time one side of it was connected, a short wire was hanging from the other side. The man was at work on a wire from the opposite terminal of the dynamo when he accidentally touched the end of the free wire, receiving through his body the 1,300 volts. The resistance of the testing device was 5,580 ohms, and of his body, from hand to hand, 6,000, so that he got a current equal to these two resistances added (11,580 ohms), divided into the 1,300 volts, or ·12 ampere. Had not the 5,580 ohms' resistance been between him and the opposite pole of the dynamo, there is no question but that he would have been killed. In that case he would have received $\frac{1,300}{6,000} = \cdot 21$ ampere.

Assuming that ·2 ampere is the quantity of current we must provide against, let us determine on an insulation. For example, we will take a circuit of 50 arc lights and a current of 2,500 volts, the insulation of the circuit measuring infinity, except at a point at the negative pole, where it is a megohm. If a man comes in contact with the conductor at the positive pole, a current will pass through him equal to $\frac{2,500}{1,000,000 + 5,000} = \cdot 0024$ of an ampere.

Let us now assume that the insulation of the circuit is a megohm equally distributed. We have 50 lamps with a potential of 2,500 volts, or 50 volts to the lamp, and a total

insulation of 1,000,000 ohms, or 50,000,000 ohms to each space between lamps. There will be a certain amount of leakage from each of these spaces, as shown in the diagram:



The dotted lines represent the leakage. The insulation from one lamp to another is $\frac{50,000,000}{2}$, or 25,000,000, and, with a potential of 100 volts (two lamps), we have a leakage or "eddy current" of $\frac{100}{25,000,000}$ = ·00004 of an ampere.

The man of 5,000 ohms' resistance comes in contact with the conductor at some point along the circuit, forming a shunt of $\frac{50,000,000 \times 5,000}{50,000,000 + 5,000} = 4,997$ ohms. Now, as he has only shunted one side of the circuit, he will get a current in proportion to the resistance of the other side, and the current will be equal to $\frac{50,000,000 \times 9,997}{50,000,000 + 9,997} = \frac{100}{4,996}$ = ·02 of an ampere, which is not at all dangerous.

Let us now assume that the circuit measures infinity, except at a point near one terminal, where it is 12,500. If he comes in contact with it at the opposite pole, he will receive a current of $\frac{2,500}{12,500 + 5,000}$ = ·14 of an ampere, which, while perhaps not dangerous, would be very uncomfortable.

If we distribute the 12,500 ohms equally, as in the case of the megohm circuits, we get 12,500 × 50 = 625,000 as the insulation of each space, which, divided by two, gives us 312,500 as a path for 100 volts, or a current of ·00032 of an ampere. From this we may assume that an insulation of 12,500 ohms equally distributed is perfectly safe for a 50-light circuit, so far as any danger to life is concerned, and we may settle upon an insulation of five times the E.M.F. as a standard. As an example of the employment of this rule, let us take the following: a 20-light arc circuit, 45-volt lamps, 20 × 45 × 5 = 4,500; $\frac{900}{4,500 + 5,000}$ = ·095 ampere, which we have shown is perfectly safe. Or we will take an incandescent circuit of 220 volts; 220 × 5 = 1,200; $\frac{220}{1,200 + 5,000}$ = ·037 of an ampere.

As to the fire question, let us first determine what causes the fire. If the wire used is of the same size as that at present employed there can be no danger of its becoming heated, so we must look to the insulation. If the current could not leak from the wire there would be no danger, but it does get away, and it escapes through the defective insulation. It is my opinion that the fire is caused by the current heating this defective insulation as it passes through it, and that heating will be in proportion to the amount of current flowing through it. For instance, if a current becomes "dead" grounded on one side, there is no danger, except that of forming another ground or an escape between the ground and the point of lowest insulation, which escape will be in proportion to the E.M.F. between those two points. Now, suppose another ground does come in; so long as neither of them offers any resistance there can be no danger, but if instead of a ground it is an escape of 500 ohms, and the potential is 2,000 volts, there will flow through this escape a current of $\frac{2,000}{500}$ = 4 amperes. If the material through which it is flowing is of an inflammable nature it is more than likely it will be ignited, or will heat sufficiently to ignite surrounding matter. Let there be two weak spots of 500 ohms each, with a potential of 2,000 volts between them, and we have $\frac{2,000}{1,000}$ = 2 amperes, which, for aught we know, may be sufficient to cause fire.

From a practical experience of eight years, I should say that an insulation of 10,000 ohms ought to be sufficient for a 50-light arc circuit, as that would permit of a leakage of but ·2 ampere with the 10,000 ohms between the points of highest potential, and this quantity of current would be very unlikely to cause fire, although it might slightly injure the insulation at that point. In view of these facts, I have always made it a point never to run a circuit on less than 10,000 ohms, unless it was a dead ground.

Although I have always held to this rule of never starting a circuit on less than 10,000 ohms, there have been occasions when the insulation dropped below that point after starting, and it has burned out at the weak point. Of course, we have no way as yet of telling when an insulation drops below a certain point after the circuit has started, but I expect before long we will be provided with a device that will indicate this.

Now, to consider the cost of maintaining the standard of insulation. We see from the foregoing that 10,000 ohms is safe, so far as any danger to life or from fire is concerned, but the question arises, is that an economical insulation for us? I shall say no, but perhaps I cannot tell why any more than an engineer can explain why it is easier to keep his steam at 80lb. than to let it fall to 75lb. and then get it back to 80lb. Our 80lb. is a megohm. Let the insulation drop below that and it is hard work to get it back again. As a cause for this let us again refer to the 50-light circuit of 2,000 volts, and an insulation of 100,000, equally distributed. This gives us 100,000 × 50 = 5,000,000, the insulation of each space between lamps; $\frac{5,000,000}{2}$ = 2,500,000, the resistance to be overcome by the leak or eddy current. Two lamps of 40 volts each would make this leakage $\frac{80}{2,500,000}$ = 0·000032 of an ampere, a very small quantity, but there are 25 groups of these leaks, the total of which is $\frac{2,000}{100,000}$ = 0·02 of an ampere, and this 0·02 of an ampere is constantly straining to enlarge itself. With the insulation of the circuit at 10,000 we would have 10,000 × 50 = 500,000 ohms to each lamp space. This, divided by two, gives us 250,000 as the path for the leak, and $\frac{80}{250,000}$ = ·0003 as the quantity of current flowing through that leak, and with the 25 groups we have $\frac{2,000}{10,000}$ = ·2 of an ampere; quite an amount of current. With the circuit at a megohm, and following up the same computations, we get but ·002 of an ampere as the amount of leakage, which is so small as to be of no consequence.

From all facts, we may come to the following conclusions:

1. That if the insulation of a circuit at the lowest point is five times the E.M.F., there will be no danger to human life.

2. That we may consider 10,000 ohms a safe insulation for a 50-light circuit, so far as any danger from fire is concerned.

3. That we find in practice that the higher our insulation, the more economical it is for us to maintain the circuits in running order, and that it is to our interest to keep the insulation as high as possible at all times.

Therefore, in establishing a standard insulation for electric light circuits, why not place it at five times the E.M.F., which, on an arc circuit of 1,000 volts, would permit of a leakage of but ·2 of an ampere—$\frac{1,000}{5,000}$ = ·2—and on an incandescent circuit of 220 volts ·1 of an ampere.—*Western Electrician.*

Papers.—Next Thursday, at the Institution of Electrical Engineers, the following papers will be read: (1) "Laboratory Notes," by Profs. Ayrton and Perry; (2) "On the Disturbances Arising from the Use of Earth for Electric Lighting Purposes," by W. H. Preece, dealing with the earthing of 10,000-volt conductors and others.

City Lighting.—The specifications and forms of tender for the public lighting of the City of London have at last been definitely settled, and will be ready to issue, we understand, next week by Colonel Heywood, from the office of the Commissioner of Sewers at the Guildhall.

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THE
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BOUND VOLUMES.

Vols. I. and II., new series, of "THE ELECTRICAL ENGINEER" *are now ready, and can be had bound in blue cloth, gilt lettered, price 8s. 6d. Subscribers can have their own copies bound for 2s. 6d., or covers for binding can be obtained, price 2s.*

NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

EXAMINATIONS.

Readers need not be afraid—it is no old parrot cry of schools, colleges, and examinations to which we desire to direct attention, but a brand-new importation from America. Of course it is another bugbear. Anything more in the shape of an examination must necessarily be so, but the question arises, is such an examination a necessity? Let us first see to what the examination refers. In America, just as in England, there have been squabbles between the insurance offices and electric lighting contractors. The offices were asked in the ordinary way to accept certain risks. Upon examining into matters, they found the risk would be all right if the workmanship was all right. Whenever anything went wrong, it was mostly traceable to bad workmanship, and in order to improve matters an exchange was started, one of the fundamental objects of which was to ensure good work.

Before pursuing this further, we may say that, according to the paper and discussion at the recent convention meeting in America, there is a risk, that of central stations, the insurance companies of America show no particular anxiety to accept. The reason given is that the central stations are mostly installed in unsuitable premises. We are glad that the tendency in England is quite different from this, and is to build or make the central station premises suitable for the work to be carried out therein.

To resume. There are certain classes of workmen engaged upon light and power installations whose carelessness or ignorance will certainly lead to troubles of various kinds. It may be only the breaking of lamps or the burning up of an armature, or it may be a serious and costly fire. The linesman or wireman is an important factor in the safety of an installation, and we have no hesitation in saying that some of these gentlemen are responsible for work carried out in London that would be a disgrace to a Hottentot, and for which they deserve incarceration in one of Her Majesty's prisons "during the term of their natural lives." Hardly any punishment is adequate as a deterrent to this kind of bad workmanship. The result may lead to frightful death, hence the condemnation of such practices cannot be too strong. Honourable firms do not countenance such things. They will not accept an offer which necessitates bad workmanship at the price. It is useless for people to argue that good "wiring" can be done at, say, ten shillings a lamp. It cannot, and though actual work done at and under this price may be quoted authoritatively against our dictum, we still retain our opinion, and trust to time to prove its correctness. Trouble arises from the workman or from the master. Assuming that the latter is not to blame, it becomes well worth consideration how far the action taken

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in America might be adopted here to ensure good work. The motive power for action there came from the insurance companies, as will be seen from the following extract from a notice of the Boston Fire Underwriters' Union: "At a meeting of the Underwriters' Committee, held January 28th, 1889, it was voted that, on and after May 1st, 1889, all electric lighting and wiring companies' men who are in any way responsible for any of the wiring, running of the dynamos, or care and management of batteries for electric lighting, must hold a license from the N. E. Electric Exchange. This rule applies to isolated plants and central stations alike, and is imperative. No exceptions will be made." This is pretty strong, and shows at any rate that the insurance companies will not be bamboozled if they can help it. They insist upon the employment of competent men, and if the work is not then carried out satisfactorily, the cause is obvious—gross carelessness or neglect. If this question is worth discussing at all in England, the initiative must come from either (1) the Institution of Electrical Engineers, or (2) the Electrical Section of the Chamber of Commerce. The subject, being a purely commercial one, is hardly fit for the Institution, while it seems just one of those which ought to commend itself to the Chamber of Commerce. There is no doubt bad workmanship, leading to failure, is always more detrimental to the prosperity of a young industry than to an old one. In the latter, firms have obtained a reputation, and it is a recognised fact that orders may confidentially be placed in their hands, while a keener supervision is kept over the work of younger firms. In a young industry all firms are more or less young together, and time has not classified them into good, bad, and indifferent, but from the very first some firms commence to stand out above others as scorning to pass bad work, and refusing to accept orders that cannot be executed satisfactorily to both parties. Of course, you may pay too much for good work, but it is always better to pay a fair price rather than a conspicuously low one. We are rather inclined to believe that examination will not be a satisfactory solution of good workmanship and competency, unless there is included an examination into "honesty." A man may be quite able to do good work, yet have no intention of so doing, and how will examination meet such a difficulty? Inspection would be as much needed under such a system as now, and no one will dispute that inspectors ought to be thoroughly competent at all points. They should not only know how, but be able to actually do the work, otherwise inspection is a sham; for books will tell you how a thing should be done, while the practical man will describe such a description as foolish and impossible. The theorist always has at command "ifs" and "assumptions," none of which lend themselves to the requirements of the practical worker. Thus we contend the inspector should be able to do, rather than say how to do. Here again the section of the Chamber of Commerce might well formulate an opinion.

THE THOMSON ELECTRIC METER.

Among the list of practical working electric meters lately discussed by Prof. Forbes, there is one of considerable interest of which no mention has yet been made. This is the Thomson meter, now used in great numbers by the Thomson-Houston Company of America for incandescent lighting on their alternate-current circuits.

The accompanying diagram illustrates the construction of the Thomson meter, in which the indication of current measurement is brought about by a reciprocating action depending upon the alternate expansion of air in two bulbs, and the consequent displacement of liquid, caused by the heating of wire resistances inserted in those bulbs.

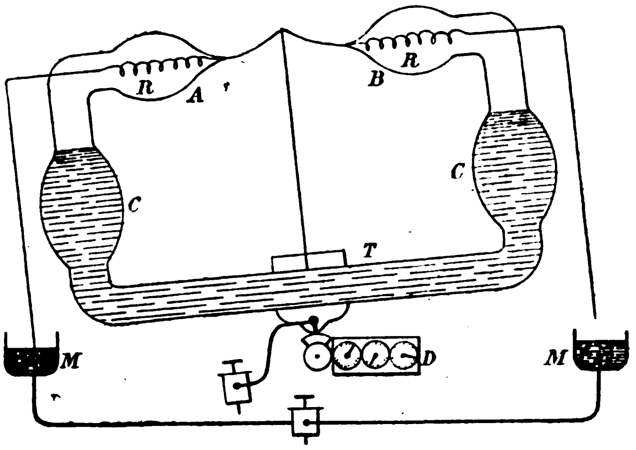

Diagram of Thomson-Houston Meter.

In the diagram, A and B are two bulbs connected together by a tube (T); the tube has also two bulbs blown in it, C, C, which are filled with kerosene oil. In the upper bulbs are small metal resistances, R, R, the inner ends of each being connected to one terminal, while the outer ends turn over and dip into two mercury cups, M, M. The glass tube is pivoted at its centre, and whichever way the tube tips, electric connection is made on that side with the mercury in the cup, through the resistance, R, contained in the bulb on the same side. The two mercury cups are connected to the other terminal.

The action is as follows: the current, or that portion of it shunted to the meter, heats the resistance; this expands the air in the bulb and forces some of the oil to the opposite side. The tube then rocks over, breaking the contact upon one side and making it on the other, when the same action is repeated. The rocker is connected to a train of wheels, and registers like the usual dial of a gas-meter. The meter is cheap and simple, and is said to have proved extremely satisfactory, and large quantities are being turned out at the factory of the Thomson-Houston Company, at Lynn, U.S.

NATIONAL ELECTRIC LIGHT ASSOCIATION (AMERICA)—MEETING AT CHICAGO.

(Continued from page 212.)

A paper was read by Mr. S. E. Barton on "Electric Light Stations as Fire Risks," which, while containing much of local interest, has some points of general interest. The writer contended that it was mutually advantageous for electric light contractors and insurance companies to work harmoniously. Of the former he said:

"Your duty is obviously to do all you can by your own work to promote and secure safety, and to encourage all feasible plans and efforts of others tending in the same direction. While the plain duty of underwriters in the public interest is first to hold to a strict line

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of requirements any of you who may be tempted or compelled, through competitive pressure, to depart from what you know are safe practices; and, having done that, the underwriters' duty is not fulfilled until they have endorsed electrical illumination and power by the reduced premium charges that such combined action on the part of electrical and insurance interests is sure to warrant. The two interests are peculiarly identical. Hand in hand they can accomplish much in reducing the enormous fire waste. Disunited and antagonistic to each other, your work will be slower in development. Competition among yourselves, and no restraining supervision on our part, will drive you to cheaper construction and maintenance of your work. More fire loss and higher premiums for insurance must inevitably be the result, while the public, still calling for your light because it is good, will be deterred to an injurious degree by reason of the increased insurance rates that will surely follow, such as have already been applied in some cases, and threatened in others. The policy of insurance companies and organisations toward electric lighting, or any hazard, in fact, capable of being minimised, should not be 'to fit the punishment to the crime,' but rather to lessen the crime, or endeavour to."

A reduction of tariff is made in some risks lighted electrically by New England insurance companies. The agent of the companies in his endeavours to get business is an advocate for such lighting, and so works for contractors. By reason of faulty work which crept in during the early stages of electric lighting at Boston, numerous small fires occurred which led to the insurance companies insisting that the responsible men in installations should hold licenses from the New England Electric Exchange.

"In regard to the electric light generating station, the situation is not a pleasing one to either party. Out of over 200 fire insurance companies doing business in Massachusetts, the electric light station is a prohibited risk with all but about 25 or 30 of them. The reasons for this interdiction are chiefly these: First, because electrical apparatus, and dynamos in particular, have been found to be very susceptible to large and uncertain damage in cases of small fires; secondly, because generating stations have too frequently been crowded into very hazardous and improper quarters, simply to get floor space and power at the smallest cost, without regard to permanency and ultimate results; lastly and mainly, because insurance men, as a rule, do not understand the nature of the hazard and often fail to get enlightenment from those in charge of stations. Therefore a large majority of the companies adopt the course of all wise underwriters—they 'take the benefit of the doubt' and leave your station risks alone."

In the discussion, Mr. Morrison agreed as to the "lamentable condition of many of the electric light stations." Mr. Barton again was touched to the heart to see what he believed to be one of the safest classes of risk "in such a condition that insurance companies will not touch it as a general rule." This seems to have been the moral of the paper. Central stations are so badly installed in America that they can with difficulty be insured. In continuation of this subject, Mr. Alexander submitted a verbal report of the "Committee on the New England Electric Exchange," an organisation designed, in March last year, to be "a mediator between what seemed then to be conflicting interests." Manufacturers, electrical engineers, and those engaged commercially were eligible as members. "The prime object always has been to look for good work. Manufacturing companies and operating companies alike had a common interest to have good work done." As has been stated above, one outcome of the exchange has been to license wirers and linemen, those in charge of dynamos, etc.

"In order to promote ambition in excellence of workmanship, and to extend the knowledge among men practically engaged in installing and operating electrical plants, and thus make it an object for fire underwriters to recommend the introduction of electricity in preference to other means of producing artificial light and power, the New England Electric Exchange will issue licenses of five classes, each class representing a certain extent of qualification. First-class licenses are issued only to persons fully competent to install and operate any electric light or electric power plant. The applicant for a first-class license must be able to make working plans for central stations and for isolated installations; must have a general knowledge of the construction of dynamo electric machines and the electrical appliances necessary for electric light and electric power installations, a general knowledge of the principles, the construction, and installation of primary and storage batteries, a thorough knowledge of the insurance rules pertaining to the business, a specific knowledge of the systems operated by the applicant, and a thorough knowledge of the calculations necessary for and the rules governing electric wiring, and be able to make complete wiring plans. From this class we go down to those requiring less and less knowledge, to men who are not competent to do electric work. Fifth-class licenses are issued to persons competent only to operate electric machinery, and who are not competent to do electric wiring. The applicant for a fifth-class license must have a general knowledge of the operation of the particular electric light or electric power machinery it is desired to operate, and a thorough knowledge of the insurance rules pertaining thereto. You can readily see what great difficulty we have in examining these different men all over the New England States. We arranged for examinations weekly in Boston, but it was a very difficult thing to bring the men there, especially as they were not forced to go there at first under insurance rules. We found a great many very eager to take advantage of this, and very eager to know exactly themselves how much knowledge they did possess, and rightly so. It was often questioned, 'Who are your examiners, and who examined your examiners,' as one man put it to me. Well, we have in New England a good many good electrical men. We had Prof. Anthony and Mr. Hill, of Boston, on practical work. We generally take three men to work together, two of whom would be good practical men, and one having a good knowledge of theory. These gentlemen have to serve right along, without pay. I want to say, that in order to make this a success, it was necessary for about 25 of us to give half a day each week to this business exclusively—to devote themselves to this matter at the loss of their own business; but they have done it; we have found men who have done it. We have now six examining boards, composed of three each, and we have five on the directing board that meets every Monday. Every safeguard was put, however, around the issuing of licenses. These examiners would examine the applicant who made application for a certain class. How few of them attained it the last official report, which dates now some months back, will show. I find that 43 men applied for first-class licenses, and only 26 obtained it. Of 45 who applied for second class, only 31 were successful, while 42 men who had applied for higher class licenses received only a fourth class. But they were quite satisfied, and we have a great many letters from them saying, 'Why, we simply go ahead and will try again.' They have a right to come again and again for examination. They have, in several cases, brought to the second examination a great deal more knowledge than they ever had, putting their whole heart into it now, having something to look forward to and to attain. They have done very well; the plan has worked well, and the men themselves have done very well. After the examiners have gone through and made their minutes of the examination, they send their report to the board of directors, who weigh that matter carefully, and either send the report back, if not in accordance with rules laid down here, or accept it. Then, before issuing these licenses, each examiner has to sign the certificate that is issued; the president and secretary have to sign the certificate; and then once more we send it to the insurance inspector of that district, who comes in personal contact with these men, and who can tell us, although they may have a knowledge of the business, the men may be careless in carrying out their work. We have also a clause by which we can revoke any license that has been given to a man who proves incompetent afterwards, or careless in his work. We have found that men perfectly able to operate electric machinery are incompetent by reason of neglect and carelessness."

In the discussion, Capt. Brophy pointed out that good reliable work meant a less number of insurance inspectors.

(*To be continued.*)

ARC LAMPS AND THEIR MECHANISM.*

BY PROF. SILVANUS P. THOMPSON, D.SC., M.I.E.E.

(*Continued from page 213*).

Experiments show that the special forms of electromagnet may be tabulated as follows:

(*a*) *Short-range Magnets.*—1. Horseshoe form, if constructed with short thick cores, thick yoke and thick armature, giving compact magnetic circuit.

2. "Pot-magnet," straight core with external tubular envelope, connected by iron at bottom. Armature, a stout iron disc or lid.

(*b*) *Moderate-range Magnets.*—1. Horseshoe form with long thin cores and armature, giving a non-compact circuit

2. Solenoid having a short fixed core extending part of the way down, and a second movable core to be attracted in as plunger. The name "stopped solenoid" is suggested as appropriate for this form.

3. Two such as last, having a yoke connecting the two fixed cores, and a second yoke connecting movable cores.

4. Stopped solenoid with plunger attached to an outer mantle (Kennedy's lamp, Fig. 10).

5. Electromagnet with conical poles protruding through hollow in armature (Thomson-Houston lamps, Figs. 14 and 25).

6. Electromagnets with oblique approach of armature. (Serrin's, Fig. 5; De Puydt's, Fig. 23; and many other lamps)

(*c*). *Long-range Magnets.*—1. Solenoid, cylindrical, with longer cylindrical core. Attraction greatest when entrant end of core just reaches the further side.

2. Solenoid, cylindrical, with long coned core entering with the point foremost.

3. Solenoid, conical, with long cylindrical core entering the thicker end of solenoid.

4. Special device for travel of unlimited length. A solenoid constructed in sections, which are switched into circuit progressively ahead of the core as the core travels down (Thomas, 578^{82}; Lindemann, 16376^{87}).†

It must be borne in mind that the range of an electromagnet depends on the relative dispositions of the iron parts of the magnetic circuit and of the magnetising copper parts, and in no way upon the question whether the coil consists of a few turns of thick wire, or of many turns of thin wire.

EQUALISERS.

In sundry forms of lamp special mechanical devices have been introduced for the purpose of equalising, throughout a given range of motion, the otherwise very unequal pull of the electromagnet upon its armature. Set-up springs with adjustable stops have been used for this purpose. A more satisfactory *equaliser* (*repartiteur*) is the device suggested by the famous conjurer, Robert Houdin, which is depicted in Fig. 1. Here the attraction of the electromagnet, E, for its armature, *a*, is transmitted through a system of two curved levers, A and B,

* Paper read before the Society of Arts, March 6th.

† Figures in parentheses relate to patent specification or date.

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which rock on one another at a point of mutual contact which varies the "mechanical advantage" of the system, and partially or wholly, according to the curvature, compensates for the great increase of force as the distance of the armature diminishes.

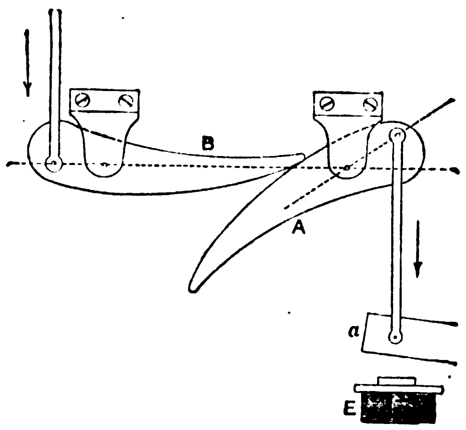

Fig. 1.—Houdin's Equaliser.

The form of the equaliser of Foucault, as used in the Foucault-Duboscq lamp, is depicted in Fig. 2. Here the armature, *a*, which is stiffly pivoted eccentrically to allow of adjustment, is attached to a lever, A, whose fulcrum is at F, and the opposing force of a spring, *s* (itself adjustable by the screw, *r*), is applied through the curved rocking lever, B. The vertical arm attached above F carries the detent, D. Equalisers depending on use of a rocking lever are to be found in several lamps. (Serrin's lamp; also Mackenzie, 95[82], and Common, 626[82]).

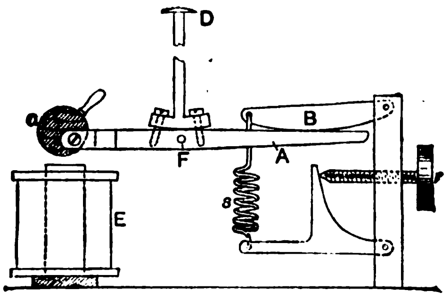

Fig. 2.—Foucault's Equaliser.

Returning from this digression, we have now to go separately over the eight items of the schedule, and point out how the various necessities have been met by the ingenuity of various inventors. As it is impossible to mention all instances of carrying out a principle, reference is made only to a few cases, preferably to the best known lamps.

(A.) Driving Power.

The following devices have been used:

1. *Gravity.*—Descent by its own weight of upper carbon-holder (innumerable lamps); ditto, aided by weights specially attached (Gulcher, 1915[82]); ditto, partially opposed by coiled spring to compensate for consumption (Siemen's, 365[83]); clockwork driven by weights (Staite, 11783[47]); lower carbon floated upward in mercury (Tommasi, 4405[79]).

2. *Coiled Spring.*—Drives by pinion and rack, or pulley and cord (Foucault, 1848, Staite, 11449[46]). Differential action of two coiled springs (Foucault-Duboscq lamp).

3. *Electromagnetic Motor.*—(*a*) Suction of core by solenoid; (*b*) electric motor rotates and drives carbon rod (Bousfield, 523[79]; Breguet, &c.); (*c*) electromagnetic vibrator drives carbon rod (Clark-Bowman, 1182[83]; Newton, 1623[83]; Pieper, 4133[83]; Holmes, 769[81].)

4 *Hot Air.*—Heated air rising from lamp drives fan to propel carbons (Varley, 5656[81].)

(B.) Striking Mechanism.

To strike the arc requires mechanical devices; but as these are to be actuated by the current itself, it is appropriate first to consider what electric mechanism is necessary or sufficient to actuate the movement. Assuming that the carbons are initially in contact when there is no current, the current when turned on must part them; the appropriate device is therefore an electromagnet (or solenoid with its core in lieu thereof) having its coils in the main circuit of the lamp. (Foucault, 1847; Staite, 11783[47], and in the vast majority of modern lamps.) If, however, the carbons are initially apart, the lamp must itself bring them together; and the appropriate device to actuate this movement will be an electromagnet (or solenoid) connected as a shunt, and therefore having fine wire coils of high resistance. Such an arrangement will bring the carbons together by the action of the by-pass current, and as this falls almost to zero on the contact of the carbons, they will be at once parted (and the arc struck) by the opposing force: this force may be that of gravity (Lontin, 1875) or a spring (Lever, 2092[83]; Thomson-Rice, Fig. 33). The disadvantage of this second method is that the initial resistance of the whole series of lamps standing with their carbons parted is enormous unless there is a cut-out circuit. Another method of striking the arc is by cutting out a main-circuit electromagnet (Crompton, 346[82]; Bright, 377[82]).

The modes of parting the carbons are various:

1. Drawing both carbons asunder by gearing (Foucault-Duboscq lamp).
2. Drawing down the lower carbon by electromagnet placed in base (Staite, 11783[47]; Serrin, Breguet, Sellon, Newton, Pieper, Holmes, &c.), or by electromagnet situated at top (Crompton "E," 1881; Gramme; Silvertown Co.; Fein, 1888).
3. Lifting upper carbon rod (Roberts, 14193[52]; Slater and Watson, 212[52]; and the vast majority of modern lamps, Brush, Siemens, Crompton, Pilsen, Brockie-Pell, Thomson-Houston, &c.), or lifting upper carbon by an electromagnet situated in the carbon rod (Abdank, 1884); or by lifting bodily the upper carbon and the whole of the feeding train (Crompton, 346[82]; Fyfe and Main, 3821[81]; Berjot, Wood, Hochhausen, Maxim, 1649[80]; Gümpel, 253[81], &c.); or by rocking the feeding train around a centre (Brockie, 2370[82]; De Puydt, Fig. 23).

The mechanical devices for performing these various actions are numerous, and their action is complicated by the endeavour of many

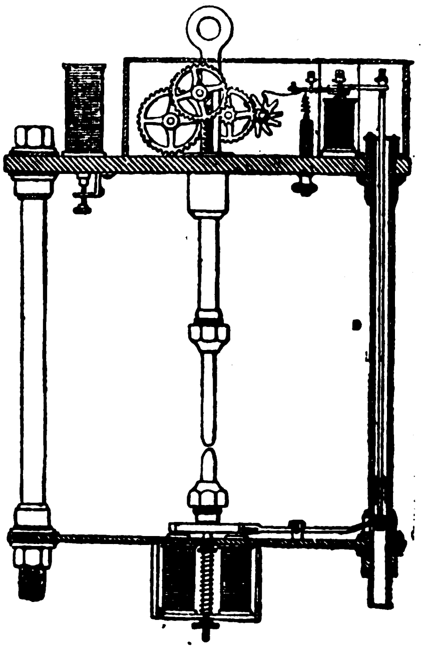

Fig. 3.—Breguet Lamp.

inventors to cause the same mechanism which initially strikes the arc also subserve the purpose of feeding the carbons. In some lamps, however, these functions are kept separate. An example of a lamp in which the striking and feeding mechanisms are kept separate is afforded by the Breguet lamp (Fig. 3), in which an electromagnet draws down the lower carbon-holder to strike the arc, whilst the feeding is accomplished in the subsequent gradual descent of the upper carbon. In the lamps of Newton, Sellon, and Holmes, there is used the special form of short-range electromagnet, *a* (2 in the list), having a central core and external tube of iron. There is a very numerous class of lamps in which a clutch is caused to grip the upper carbon-holder, and then to raise it so as to strike the arc; the same clutch being subsequently so operated as to permit the carbon-holder—a smooth rod—to slide down by degrees as required, to feed the carbon pencil forward. Such devices are best considered under the heading of feeding mechanisms.

The adjustments of the striking mechanism may be of two kinds: (1) adjustments of range, such as limiting stops and set screws; (2) adjustments of force, such as regulable spring shown in Fig. 1 at the bottom.

The main-circuit electromagnets, and solenoids, used for striking the arc, are wound with a wire of large enough section to carry the required current without undue heating, and are of small resistance. The weight of copper wire employed varies from one to four pounds; and the resistance varies from 0·05 to 0·2 ohms.

(C.) Feeding Mechanism.

The electric devices here differ in the case of lamps for parallel working and lamps for series working.

(*i.*) *For Lamps in Parallel.*—Assuming that the supply mains are kept at constant potential, then the lamp mechanism must be responsible for keeping the other factor of the electric power—namely, the current through the lamp—at a constant value. That is say, whenever by reason of the burning away of the carbon points the arc grows long, offering more resistance, and therefore reducing the current below its normal value, the lamp must automatically feed the pencils forward, and so readjust the current. It is obvious that, in this case, the weakening of the current through the lamp may be caused to bring the feeding mechanism into operation by the use of an electromagnet (or solenoid) in the main circuit. For if the armature of this electromagnet be held back by a spring or weight which only just counterbalances the pull of the magnet when the current is normal, the weakening the current will at once cause a movement of the armature which may be utilised to relax a clutch, lift a detent, or release an escapement. And it is also obvious that in this case it is possible to arrange the same electromagnet which strikes the arc to actuate the feed. Examples of the use of a single main-circuit electromagnet to actuate both the striking and the feeding mechanisms are to be found

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in the Serrin lamp, in the Gulcher lamp, and in the Brush lamp as arranged for parallel working.

(*ii.*) *For Lamps in Series.*—Assuming that the dynamo is doing its duty, and keeping the current constant, then in this case the lamp mechanism must be responsible solely for keeping constant the potential between the terminals. Whenever by reason of the burning away of the carbons the arc lengthens and offers more resistance, if the same current is still supplied to it and forced through this greater resistance it will burn more brightly, and the difference of potentials between the terminals of the lamp will rise above its normal value The lamp must then automatically bring its carbons nearer, and readjust the potentials to the proper number of volts. It is obvious that the appropriate device to actuate the feeding mechanism must, in this case, be something that can play the part of a voltmeter; and will actuate the mechanism when the volts rise above their normal value. Practical voltmeters are of two kinds; (*i*) those which depend on the magnetic effects of the current that will flow through a wire of high resistance placed as a shunt across the two points between which the differences of potential exists, and (*ii*) those which depend on the heating effects of the current in such a wire. Either of these effects may be used to control the feeding mechanism of arc lamps; that is to say, the feed must be controlled by a shunt circuit, which will actuate the mechanism as soon as the potential rises above its normal value. The usual device is an electromagnet (or solenoid) of fine wire and of high resistance (from 200 to 400 ohms), the armature of which is counterbalanced by the force of a spring, or by gravity, or by an opposing main circuit electromagnet (or solenoid). An alternative device, not, however, in general use, is a long, thin platinum wire, which when heated by a current above the normal value will expand and actuate the feed. Thermal expansion has been attempted as a method of regulation by several inventors. (Lontin, 2074^{77}; Siemens, 2281^{78} and 2110^{79}; Munro, 1626^{82}; Edison, 2072^{82}; Pollak, 1888, &c.)

In the following table are comprised the several electrical arrangements for controlling the feeding mechanism:

(*i.*) *Constant Potential Lamps* (*for Parallel Working*).

(*a.*) Series electromagnet, same as used for striking. (Serrin; Gulcher; Brush; Crompton, &c.)

(*b.*) Series electromagnet, separate from the striking electromagnet. (Fontaine.)

(*c.*) Differential arrangement. Series winding partly opposed in shunt winding, on separate cores or parts of mechanism. (Lacassagne and Thiers, 2456^{56}; Siemens; Brockie-Pell.)

(*d.*) Ditto but wound on same cores.

(*ii.*) *Constant Current Lamps* (*for Series Working*).

(*a.*) Shunt electromagnet alone, acting against gravity or spring. (Lontin, 1877; Lever.)

(*b.*) Shunt electromagnet separate from the striking (series) electromagnet. (Numerous lamps. Breguet (Fig. 1); Crompton "E"; Sellon; Gramme; Pieper.)

(*c.*) Differential arrangement. Shunt winding pulling against series winding, on separate part of mechanism. (Lacassagne and Thiers; Siemens "differential"; Pilsen; Crompton-Crabb "DD"; Thomson-Houston; Brockie-Pell; Kennedy.)

(*d.*) Differential winding. (Numerous lamps. Brush; Weston; "Simplex.")

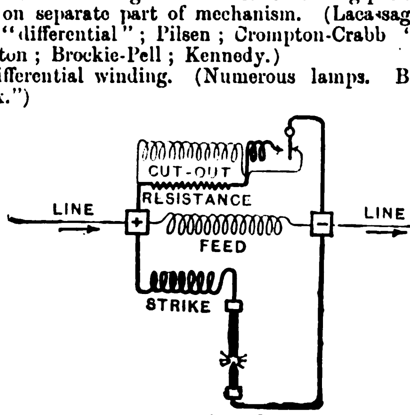

FIG. 4.

The typical arrangement of circuits for lamps that are to be run on a system of arc lighting in series, is shown in a generalised diagram in Fig. 4. The striking coil is in the main circuit; the feeding coil is a shunt, which if wound on the same core as the series-coil in any of the differential systems must be so wound that the currents circulate in opposing senses. There is also added a cut-out circuit, having both a shunt-coil and a small series-coil; but these must be so wound as to help one another's magnetic power, and the small series-coil must itself be a shunt to the main circuit of the lamp.

We are now prepared to enter upon the mechanical devices which have been suggested for the feeding mechanism of lamps. These are so varied, and run so curiously into one another, that no classification of them is entirely satisfactory. In a very large class of lamps there is a train of wheel work, usually driven by the weight of the descending carbon rods, the last member of the train being controlled through a detent or brake by the electromagnet that is responsible for the feeding of the lamp. Most, but not all, of these lamps have a rack upon the upper carbon rod to drive the train. But the rack lamps differ greatly amongst themselves. Again, there is another class of lamps in which the upper carbon rod is smooth, but is assisted and controlled in its descent by a clutch or clamp, the clutch or clamp being in turn controlled by the feeding electromagnet. But there are also rack lamps in which a clutch or clamp is applied, not to the rod itself, but to a wheel driven by the descending rack. There are, however, certain main features of classification about which there need be no ambiguity.

FEED MOTIONS.

(*i.*) *Rack and Train* controlled by—
(*a.*) Star wheel and detent (Staite, 18783^{47}; Foucault-Duboscq; Serrin, 653^{58}).
(*b.*) Fly and detent (Staite, 1848; Duboscq, 1855).
(*c.*) Brake-wheel and brake (Chapman, 739^{55}; Crompton, 346^{82}).
(*d.*) Escapement with pendulum or balance and detent (Siemens, 4949^{78}; Harding, 3166^{81}; Waterhouse, 5185^{81}).
(*e.*) Escapement and paddle (Waterhouse, 5185^{81}).
(*f.*) Governor with detent or moderator (Waterhouse, 5185^{81}).
(*g.*) Magnetic brake-wheel or detent (Brockie, 1713^{82}; Harling, 3473^{81}).
(*h.*) Liquid brake (Hopkinson, 153^{81}).

(*ii.*) *Clutch or Clamp on Rod*—
(*a.*) Tilting ring, tilting eyelet, &c. (Slater and Watson, 212^{52}; Brush, 2003^{78}; Lumley, 1249^{82}; Lever, 2092^{82}; Thomson-Houston; Waterhouse, &c.).
(*b.*) Split cone gripped by fork (Slater and Watson, 212^{52}).
(*c.*) Split nozzle forced into cone mouthpiece (Bürgin, 4820^{81}).
(*d.*) Split tube held together by oblique levers (Rogers, 3236^{82}).
(*e.*) Gripping springs at side (Lever, 3599^{81}; Munro, 1626^{82}).
(*f.*) Gripping fingers (Roberts, 14198^{52}; Joel, 5157^{79}; "devil's claws," Harding, 3166^{81}).
(*g.*) Washer jambed by ball bearing (Young, 1689^{82}; or roller, Newton, 4559^{81}).
(*h.*) Tilting clamp or nipping clamp (Common, 625^{82}).
(*j.*) Nipping lever (Grimstone, 1670^{81}; Mondos, 5490^{81}).
(*k.*) Scissors lever (Joel, 3970^{84}; Jarman, 563^{82}; Gerard-Lescuyer, 2992^{82}).
(*l.*) Spiral spring surrounding rod (Keilhotz, 1886; Thouvenot, 1887).
(*m.*) Forward-pointing springs (lobster trap) (Newton, 1623^{83}; Clark-Bowman, 1182^{83}; Holmes, 769^{86}; Hawkes, 157^{82}).

(*iii.*) *Clutch-wheel or Brake-wheel*—
(*a.*) Nipping lever outside brake-wheel (Gramme, 1861; Common and Joel, 1041^{81}; Brockie, 4419^{82}).
(*b.*) Nipping lever inside rim of wheel (Union Co., 392^{82}; Brockie, 4419^{82}).
(*c.*) Elastic band brake (Statter, 2985^{85}).
(*d.*) Elastic internal ring brake (Siemens, 6987^{87}; Fein, 1888).
(*e.*) Wheel lifted against brake or detent (Bürgin, 4820^{81}).
(*f.*) Brake-wheel lifted upon brake lever (Gümpel, 253^{81}; Crompton-Crabb, 2539^{83}).
(*g.*) Friction-pad on rim of wheel (Abdank, 1882).

(*iv.*) *Screw Motion.*
(*a.*) Screw worked by weight of upper rod (Hopkinson and Muirhead, 153^{81}; Cance, 3976^{81}; Akester, 2419^{82}).
(*b.*) Screw worked by motor (Tchikoleff, 1874).
(*c.*) Screw worked by step-feed (Street-Maquaire, 9666^{85}).
(*d.*) Screw worked by vibrated wheel (Siemens, 6987^{87}).

(*v.*) *Cord and Pulley Motions*—
(*a.*) Cord and pulley to core of solenoid (Archereau, 1848; Jaspar, 83^{79}).
(*b.*) Cord and pulley connecting carbons, with long-travel solenoid (Pilsen lamp, 1397^{80}; Doubrava, 1033^{84}).
(*c.*) Cord gripped by controlling cam (Harding, 4590^{79}).
(*d*). Cord and pulley for differential feed (Weston, 1883; Kennedy, 1888).

(*vi.*) *Step-by-Step Motions*—
(*a.*) Step detent worked by electromagnet (Deleuil, 1856; Brockie, 898^{82}; Gatehouse and Kempe, 2569^{82}; Kennedy, 5524^{81}).

(*vii*). *Magnetic Clamps and Clutches*—
(*a.*) Tilting magnet clutch on rod (Roberts, 14198^{52}; Gulcher, 2038^{81}).
(*b.*) Magnetic clamp on break-wheel (Harling and Hartmann, 3473^{81}; Hardt, 1886).

(*viii.*) *Electric Motor Action*—
(*a.*) Motor screws carbon up or down (Tchikoleff, 1874, and 2198^{81}; Maquaire, 1889).
(*b.*) Winds up with cord or rack (Andrews, 2321^{79}; André, 2764^{80}; Bousfield, 523^{79}; Breguet, 1879).
(*c.*) Motor itself controlled by shunt magnet (Thomson-Houston, 315^{80}).
(*d.*) Motor with copper damper (Thury, 1888).

(*ix.*) *Hydrostatic and Pneumatic Action*—
(*a.*) Carbons controlled by admission of liquid or gas (Lacassagne and Theirs, 2456^{56}; Hopkinson, 3509^{80}; Leibold, 1886; Sedlaczek, 1883).

(*x.*) *Vibrating Feeds*—
(*a.*) Make-and-break lever vibrate forward-pointing springs (Newton, 1623^{83}; Pieper, 4647^{85}; Holmes, 769^{86}).
(*b.*) Make-and-break lever actuates escapement (Harding, 3166^{81}).
(*c.*) Make-and-break lever actuates detent on train (Gramme, 1880).
(*d.*) Make-and-break lever hammers rod through clutch (Letang, 5509^{87}).
(*e.*) Make-and-break lever works internal clutch-wheel feed (Fein, 1888).
(*f.*) Make-and-break lever drives pallet and screw feed (Siemens (Alteneck), 1885).

(*xi.*) *Periodic Feeds*—
(*a.*) Periodic drop of upper carbon and lift through definite range (Brockie, 898^{82} and 1713^{82}).
(*b.*) Periodic currents to magnet sent through second wire (André, 4948^{81}).

(*xii.*) *Continuous Feeds*—
(*a.*) Clockwork step feed, length of stroke varied by magnet (Brockie 898^{82}).

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(*b.*) Pendulum or governor, having rate varied by magnet (Waterhouse, 5185[81]).
(*c.*) Rack-train controlled by magnetic retardation on copper wheel (Niaudet, 1878).
(*viii.*) *Hammering Feeds*.—
(*a.*) Rod driven through clutch by vibrating hammer (Letang, 5509[87]; Capito and Hardt, 1887).
(*b.*) Ditto, by tilting lever (Jolin, 2570[83]).
(*c.*) Ditto, by magnetic pile-driver on rod (King, 1888).

Outside the classification adopted above are several well-marked features of mechanism; one of these is the *parallelogram motion*. A typical case of this is afforded by the well-known Serrin (653[59]) lamp (Fig. 5). A jointed parallelogram is constituted by the pieces which meet at A B C D. The side, A C, is fixed, being part of the frame, whilst the levers, A B C D, rise and fall through a small angle, carrying with them the upright, B D. To this upright is fastened a sleeve, through which the lower carbon-holder passes. This moving parallelogram is held up by a spring, *s*. When the electromagnet, E (in main circuit), attracts its armature, *a*, the parallelogram, and with it the lower carbon, sinks, and so the arc is struck. At the same instant a projecting triangular detent, U, engages against the star wheel of the driven train and locks it, so that the upper carbon cannot descend. As the carbons are consumed the current is weakened, owing to the increasing resistance of the lengthening arc, and the electromagnet lessens its attraction; consequently the parallelogram gradually rises, until a moment occurs when the detent ceases to lock the star wheel. The upper carbon-holder is now free to descend a little, driving the train of wheels, shortening the arc, restoring the normal current, and so again causing the electromagnet to pull down the parallelogram and lock the wheels. Parallelogram motions are to be found also in Bürgin's lamp (4820[81]), and in Siemens' pendulum lamp (4949[78]).

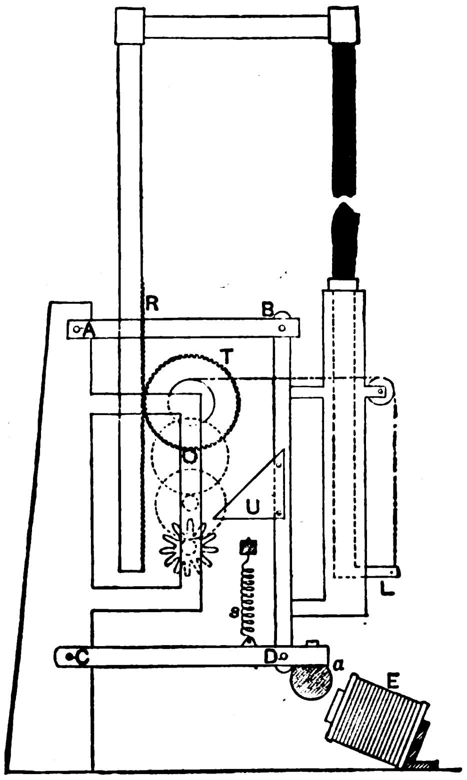

Fig. 5.—Serrin's Lamp.

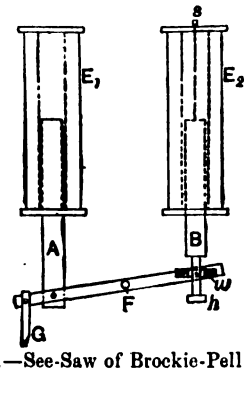

Fig. 6.—See-Saw of Brockie-Pell Lamp.

Another characteristic mechanism is the *see-saw* lever. Fig. 6 shows the form used in the Brockie-Pell lamp (12681[85]). The earliest use of the see-saw, attracted at opposite ends by series and shunt magnets respectively, occurs in the lamp of Lacassagne and Theirs (2456[56]); whilst modern examples are Weston's lamp, the Thomson-Houston lamp (Fig. 14), and Fein's lamp of 1883. (Also Moffat and Chichester, 3441[81]; and Chadburn, 2755[81], where the see-saw works a clutch). A compact modification of the see-saw mechanism occurs in one form of Weston's lamp, and again in Kennedy's lamp of 1888 (Fig. 10). Here the lever is replaced by a pulley over which passes a cord or ribbon of metal. In this lamp the shunt solenoid is furnished with a plunger core, whilst the series solenoid on the left has a plunger and an external iron mantle to increase its power. The smaller pulley communicates the motion to a clutch. The advantage of the see-saw, and of its pulley equivalent, is that such an arrangement enables the lamp to be used as either a constant potential lamp or as a constant current lamp. In the former case the shunt-coil holds up its end, whilst the see-saw is operated by the variations of the current in the series-coil. In the latter case the actions are the inverse of this.

The *rack-train* mechanism which forms the first class in the preceding list, presents two special points. As this mechanism is in itself non-retractile, and can only propel the carbons forward, it cannot be used with non-homogeneous carbons of second quality unless special provision is made in the striking mechanism of the lamp for a retractile movement. There is nothing retractile, for example, about the Breguet lamp (Fig. 3), but there is about the Serrin (Fig. 5), for the lower carbon-holder (which descends to strike the arc) is never held tight down by the electromagnet, but takes up a position of equilibrium. The other point is that in these rack-train lamps some device is requisite to lock the train at the instant of striking, otherwise the feed motion would neutralise the strike motion. In some lamps (Breguet, Sellon, &c.,) there is a mechanical connection from the striking part to lock the feed. In some other lamps the action is performed electrically. In the De Puydt lamp (Fig. 24), a pin on the train frame engages with a forked connecting-piece from the feeding-lever.

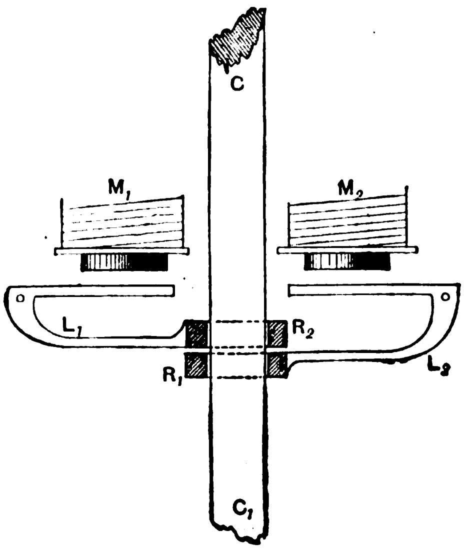

Fig. 7.—Slater and Watson's Clutch.

A characteristic arrangement, applicable to rack-train lamps, is that in which, for the purpose of striking the arc, the whole train mounted in its framework, together with the rack and the upper carbon rod, is bodily lifted by the use of an electromagnet in the main circuit. (Crompton, 346[82]; Fyfe and Main, Hochhausen, Gümpel, Berjot, Wood, Maxim, &c.) More neat is the method of rocking the train bodily around the axis of one of the wheels of the train. (Brockie, 2370[82]; and De Puydt, Fig. 23.)

Passing from the *rack-train* lamps to the *clutch* lamps, it may be noted how much ingenuity has been expended in attempting to find a form of clutch which will prove reliable under all conditions of working. Two of the very earliest forms of clutch mechanism are worth recalling in this connection. These are both due to Slater and Watson (212[52]). The first (Fig. 7) shows a carbon rod sliding through a couple of rings or eyelets, which are tilted by the attraction of an electromagnet to grip and raise the rod. In the second (Fig. 8) the clutch consists of a split conical washer, the two halves of which are hinged together. These are compressed by the rising of a fork, which nips and raises them. The tilting ring introduced by Brush is too well

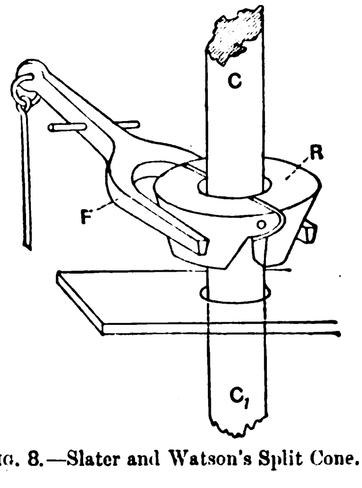

Fig. 8.—Slater and Watson's Split Cone.

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known to need comment. Lever's modification of the tilting ring is shown in Fig. 9, the rim below the ring causing the thrust to act more obliquely at first, and allowing the clutch to work even when the aperture is considerably worn. In the latest forms of this clutch, the ring has a tail-piece which is hinged to the frame of the lamp.

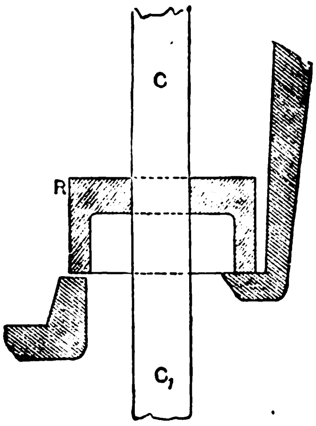

FIG. 9.—Lever's Clutch.

Another successful form of tilting clutch is shown in Fig. 10, which represents the mechanism of Kennedy's lamp. The clutch has a long tail, provided with an adjusting screw to regulate its position, and bears against the carbon rod by a slender spring, *s*, above. It is

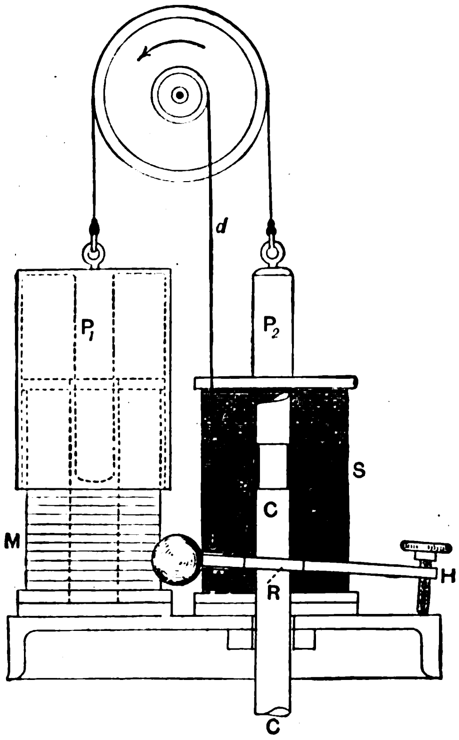

FIG. 10.—Kennedy's Lamp.

worked by a thin cord, *d*, running over a pulley in connection with the differential arrangement of shunt, S, and series, M, solenoids described above. A clutch provided with a spring that bears against the carbon rod is also found in the Clark-Bowman lamp (1182^{83}), the

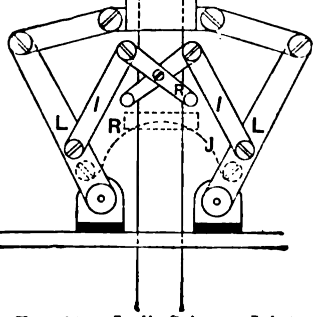

FIG. 11.—Joel's Scissors Joint.

feeding in this case being accomplished whilst the clutch is held up, by giving to it a mechanical vibration. In the Kennedy lamp the spring on the clutch also serves the purpose of finally arresting the descent of the carbon-holder, catching on a groove cut around its upper end when the carbon pencil is all consumed. Another simple clutch with spring mounting, worked by the mutual repulsion between two similarly magnetised cores, has been devised by Swinburne (11893^{84}). Clutches of the knee-lever type have been devised by Lorrain (183^{83}) and Joel (3970^{81}). The more complex "scissors-joint" levers, used in one of Joel's lamps, are drawn in Fig. 11. Their action is obvious, as their upper end is raised by the upward pull of the electromagnet or solenoid they grip, and raise the carbon rod, and

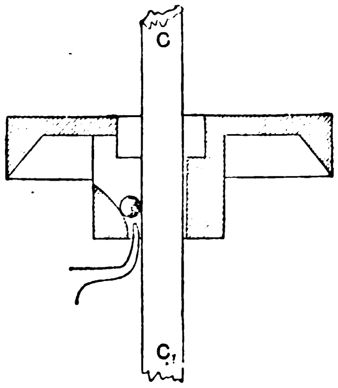

FIG. 12.—Newton's Roller Clutch.

they relax their grip on being lowered to feed the arc. Very similar devices are found in Gerard's and Jarman's lamps. An ingenious

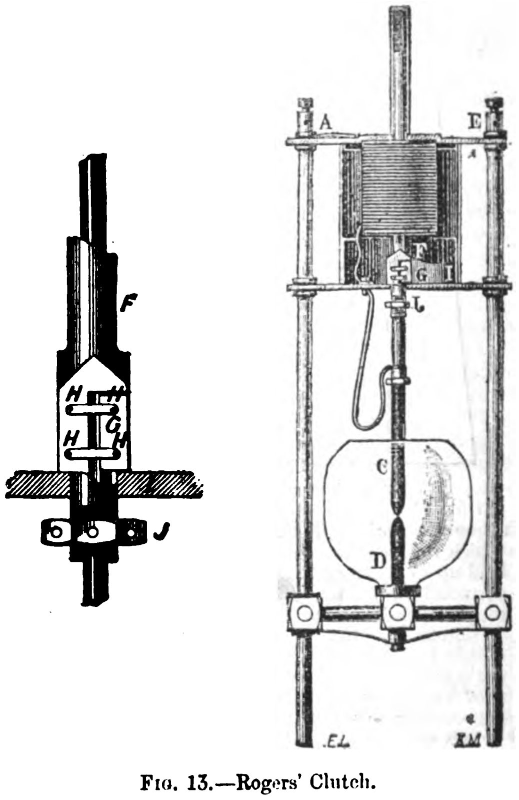

FIG. 13.—Rogers' Clutch.

species of clutch, by F. M. Newton (4559^{81}), is illustrated in Fig. 12. This consists of a ball bearing or roller bearing, which on the raising of the collar in which it lies jams against the carbon rod and raises it. Another extremely simple clutch (Lorrain, 639^{82}) consists of a plunger working horizontally through a solenoid, pressed sideways by a spiral spring against the carbon rod; the pressure of this is taken off, when feeding is required, by the pull due to the current in the solenoid, which is connected as a shunt. Rogers' (3236^{82}) simple and very efficient form of clutch consists of a split tube, the parts of which are connected together by a pair of oblique links, making a sort of parallel motion. This form is shown in Fig. 13.

(*To be Continued*).

SOME ELECTRIC LIGHTING CENTRAL STATIONS IN EUROPE AND THEIR LESSONS.*

BY PROF. GEORGE FORBES, F.R.SS. (L. AND E.), MEMBER.

(*Continued from page 201.*)

Erratum.—On page 200, line 39, in our issue of March 8, for "converters" read "feeders."

Rome.

The station at Rome, started by the gas company in that city, is the finest example of an alternating-current central station

* Paper read before the Institution of Electrical Engineers, Feb. 28.

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which I have yet seen. But it has been very costly to establish. Many of the details contain hints of the greatest use to those who are at work on this subject. The whole plant has been contracted for by Messrs. Ganz, of Buda-Pesth.

There are two self-exciting alternators of 150 h.p. each and two independently excited ones of 600 h.p. each. These give 42 amperes and 160 amperes respectively, and 2,000 volts. At present 9,000 glow lamps of 16 c.p. are supplied, and over 200 arc lamps. All the machines are capable of working in parallel, even the large and small ones together. The number of alternations is 5,000 per minute, or 2,500 complete periods. The greatest distance to which current is at present supplied is 4½ kilometres, or about three miles. The feeders all go to the Piazza Venezia, and then branch off into three mains in different directions. The loss in the secondary circuits due to loss in the feeders at present is only 0·6 volt at the maximum, and that due to the mains is the same, the length of feeders being 1,600 metres.

Siemens' concentric conductors are used throughout. The feeders are each 220 square millimetres section, or 0·35in. Drawings of the junction boxes by Siemens and Halske are shown, indicating the means of attachment by clamps of the two ends of the inner and outer concentric cores. The cables are laid in a wooden box, which is then filled with cement. Seventeen kilometres of cables have been laid up to January, 1889. The feeders have been working since September, 1887. The transformers are all of 10 h.p., with about 4 amperes in the primary and 75 in the secondary. One hundred and ten volts are used in the secondary; but the secondary coil has three terminals—one half-way along the length of wire. This is to enable a three-wire system to be used for the secondaries when arc lamps are used, consuming, with their resistances, 55 volts each.

The old type of converter, with iron wire wound round the copper coils has been abolished. The iron part is built up of circular flat ring-shaped discs of iron. These are firmly clamped together by iron clamps, which form the support of the instrument. The copper coils are wound upon the segments of the rings between the clamps. The primary coil is underneath the secondary. The converter has an iron circular disc at top and bottom fixed to the clamps, and this enables the instrument to be easily rolled about without injury, which facilitates handling. On the top is a porcelain disc, on which are placed the terminals and fusible cut-outs. These are short strips of thin metal held in pasteboard, and can be slipped in and out with the greatest ease.

The small machines are intended to work 1,000 lamps of 60 watts. There are 20 poles, and 250 revolutions per minute. A derivation is taken from a commutator to excite the machine. Sulze engines are used for these dynamos, acting direct on the dynamos. The steam pressure is 120lb.

The automatic resistance for regulating the exciting current, invented by M. Blathy, is very effective. The exciting current passes through a solenoid actuating an iron rod which is supported at one end of a balanced lever. The bar is weighted with a float in water, and water can be put into the float. On the top of the iron bar is a cup of mercury which, in falling, breaks contact with the ends of wires dipping down into the mercury cup. These ends are at different depths, so that the wires are cut out of circuit in succession. The wires go to resistances. This automatic adjustment acts well over a considerable range.

The exciters for the large dynamos are driven by Westinghouse engines. They are governed by hand for the large changes, and then the automatic regulation comes in. Such a method of regulation is necessary with machines having so large an amount of self-induction. This is the only satisfactory regulation of the kind which I have seen at work. It is one of the small details on which the success of a station depends, but which are often forgotten by the inexperienced until the want is

The two large machines have 40 poles each on the revolving field-magnets. Both field-magnets and armature are divided into two series in parallel. When the machine is illuminated by an arc light, to which it supplies the current, a curious optical effect is produced. The arc being periodically made and broken, the revolving magnet-poles are seen fixed in position, and the amount of lag with different loads can be seen directly. The efficiency of these machines is said to be 90 per cent., including the exciting current. These machines are so constructed that the cover which contains the armature-coils can be drawn away, by means of a handle, shown in the photographs exhibited, over the electromagnet ring, without the necessity of using any hoisting tackle or other machinery. Moreover, the construction of the fixed armature is such that any single coil can be removed in a few minutes or exchanged. The iron of a section of the armature is in this case removed with the coil. The iron plates of which these armature sections are made are T-shaped, so that the centre of the coil is filled with iron. In the smaller machines there is not nearly so much iron in the coils. In the 600 h.p. machines the energy absorbed in exciting at full load is said to be 3½ per cent. of the full load.

The T-shaped iron plates of the armature are pressed together by strong bronze press-plates and a screw. The wire bobbin is then slid on and held by screws. These segments are fastened to two traversers by the screws, which traversers are in turn screwed with an insulating layer to the side-plates of the framework of the machine.

The field-magnet wheel is constructed as follows: U-shaped soft iron sheets are so arranged together as to form a star, to which is added a similar star, with an insulating layer between, placed in such a way that the interstices between the sheets composing the lower star are covered by the sheets of the upper star. In this way many iron laminæ are put one upon the other until there are sufficient to form the whole electromagnet wheel. The pile so formed is then pressed together to form a compact whole by means of two stiff discs, two bosses, and the screws. The bobbins are slipped on to the core, and held down by means of the bobbin-holder and screws. The subdivision of the iron in the field-magnets is necessitated by the teeth of iron in the armature projecting inwards through the coils.

The large engines are by Ganz and Co. They are carefully balanced, and are provided with starting gear. A drawing was exhibited of the switchboard, which is very ingenious but very expensive. The board is about 8ft. high and 17ft. long. It is divided into four sections, one for each dynamo, and each section is divided into six, one for each pair of feeders. A pair of 4ft. horizontal bars runs along each dynamo section, connected with the two poles of the dynamo. Two vertical bars descend from these at each of the six parts allotted to the six circuits. Six pairs of horizontal bars are connected to the six pairs of feeders (only three are as yet in use), these pairs being one over the other. At each feeder section a pair of vertical copper bars descend from the horizontal feeder bars corresponding to that section. Thus we have at each feeder section two vertical dynamo bars and two vertical feeder bars, the lower ends all being at the same level. Mercury cups can be raised to connect each dynamo bar with a feeder bar, or lowered to disconnect them. The chief object of the switchboard is to enable us to switch any number of dynamos in or out of connection with any feeders simultaneously and instantaneously. I will now describe this action, referring to the diagram. In the normal condition of the crank and handle would be as shown in the side elevation, one crank to each mercury cup. If it be required to put on to the dynamo the feeder No. 6, and take off No. 1 from the dynamo, represented by this part of the switchboard, the handles, with cranks, corresponding to these feeders are pushed bodily to the left. The web of each crank is thus made to fit in a vertical slot in the disc, which disc is connected to the bevel wheel by a hollow spindle to which the bevel wheel is keyed, this bevel wheel gearing with the bevel wheel keyed on to the shaft, running the whole length of the switchboard. The crank of No. 6 would be diametrically opposite that at No. 1, since one was disconnected and the other connected to a circuit. The lever is then thrown over against the other stop, causing the crank No. 6 to be raised from its lowest to its highest position, and that of No. 1 to be correspondingly lowered.

The voltmeters in this station by which the pressure at the lamps is kept constant are regulated by means of two circuits, one being a shunt on the dynamo terminals, and the other carrying the main current. These are passed through converters, and the secondary currents actuate a solenoid in opposite directions. This compound-wound voltmeter indicates the pressure at the lamps, and is maintained constant. Prof. Mengarini has devised an ingenious recording voltmeter for marking in a daily curve the pressure at the dynamo terminals at each minute of time. These show variations of 5 volts at different hours.

There are 50 converters now at work, each of 10 h.p. The efficiency of these converters is 95 per cent. at full load. That of Messrs. Ganz's 5 h.p. converters is 92 per cent., and the 2½ h.p. is 88 per cent. This is far higher than with many of those now made in England. The House of Parliament is lighted by four banks of five converters each.

PART II.

Lessons to be Learned from Foreign Central Station Lighting.

I propose now to deal with some of the problems of central station lighting which we in London have now to face.

I judge by the practices I see common in this country that I shall, as to my opinions on many points, be at variance with some of my brother engineers, because in the work which has hitherto been done I see that the experience of foreign countries has very often been neglected, and the rule seems to be to neglect the opportunity of utilising the experience gained at great expense of time and money in foreign countries, while our progress was being retarded by the Electric Lighting Act. But my conclusions have been arrived at after a most careful consideration of the successful work which has been done in Europe and America, and I am ready to condemn foreign practice when

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necessary. All I say is, that we ought to benefit by the experience abroad, and I know that those who have the best interests of electric lighting in England at heart agree with me.

This neglect of the principles laid down in other countries I find to exist whether the central station be used for continuous or alternating currents. I foresee great danger in store for us if we do not discuss the difficulties fully at the outset, and I trust that the discussion that this part of my paper will give rise to will assist to make the progress now being made in England a thorough success.

Three-Wire System.

My first remarks will be about the direct system of supply at low pressure—a system which may be much more frequently employed with advantage than many people seem to imagine. It is not suited for a large district, but it has some advantages. 1. That the steadiness of the light can be increased, the fear of accidents diminished, and the amount of machinery reduced, by the employment of storage batteries. 2. If batteries are not used, the loss of energy in transformation is avoided.

Let us deal first with the case where all the dynamos are working in parallel at the same pressure. This is the Edison plan, and is very generally adopted. I have shown in my Cantor Lectures* that when we extend beyond a certain distance from the central station on the system at present used, the question of economy, as established by Sir William Thomson's law for the size of conductors, must be partially abandoned, and a different size used, in order to prevent the variation of electrical pressure over the area being too considerable under the varying loads. With the "two-wire" system the law of economy holds only up to a very short distance; with the "three-wire" the distance is doubled. This is due to the fact that the pressure is doubled, and this is the principal advantage possessed by the three-wire system. In Berlin and Milan the two-wire system has hitherto been adopted, and the enormous amount of capital expended in copper is a proof of the costliness of the system. I hold that in no case of central station work at low pressure ought the two-wire system to be adopted. In this I am supported by the universal practice in America, where the two-wire system for low-pressure distribution is now totally abandoned. I am also supported in this by the practice in Berlin, where all future work is to be done on the three-wire system. In spite of these considerations, I am not aware of a single case where it is in actual use in England since the experiments at Leamington have been abandoned. The two-wire system is used at a good many places in this country. The result of experience probably is that the three-wire system can be profitably worked to a maximum limit of half a mile where the price of gas is over 5s. per 1,000 cubic feet. Beyond that distance the profits diminish too much. In London I do not think it could be well done beyond 400 yards, as a general rule.

Feeders.

I now come to another principle of distribution, which is strangely, and, I believe, almost universally, neglected in this country. I refer to the use of "feeders." Let me distinguish between the use of feeders and mains. Mains are conductors from all parts of which branches may be laid into the houses. Feeders are conductors leading from the central station to various points in the system of mains, and which are not tapped on the road. In Berlin and Milan the practice, first started in America, is followed of laying down a network of mains and supplying current at numerous points in them by means of feeders. This serves to equalise the pressure over the entire districts under varying loads. In England this practice is not generally adopted. The result is that if you wander over a district supplied by electric light in England, you find that when the supply of current is small the lamps are equally bright over the whole town; but when there is a large demand for light, the glow lamps near the station are far too bright, and those at a distance are far too dull. In Berlin, where half the capital spent in conductors has been used for feeders, the lamps are, all over the district, equally bright at all times. Not the slightest difference can be perceived at different hours of the day or night. I hold the opinion that a station with low-tension current without feeders is badly engineered.

Using Dynamos at Different Pressures.

It is the universal practice abroad to make the size of the feeders such that the loss of pressure in these feeders is the same in all. This involves the use of very large feeders when their length is great, and great waste of energy when the length of feeder is small, but it enables all the feeders to be supplied by dynamos at the same pressure, which may therefore work in parallel. This arrangement is simple to work, but it is wasteful. I find that we can save enormously in copper at a slight extra trouble in working the central station. I would prefer to see the feeders divided into two or three groups, feeders in each group having the same length, and having the same loss of pressure.

* Cantor Lectures, "On the Distribution of Electricity," Society of Arts *Journal*, 1885.

All these feeders would be made of the economical section, according to Sir William Thomson's law. When the station is at full load, the dynamos working long feeders have a higher pressure than those working short feeders. When the load is light all the dynamos would work at the same pressure, because the loss in the feeders is insignificant. At such times all the dynamos might be joined in parallel, or the feeders might all be upon one dynamo.

Position of Pilot Wires.

In nearly all cases of low-pressure distribution the pressure is regulated by a "pilot wire" coming from the point where the feeder meets the main. These pilot wires indicate the pressure at those points upon a voltmeter at the station, which is kept at constant reading by an attendant. Sometimes all the different pilot wires are grouped together at the station and indicate the average pressure on the voltmeter. This is done at Berlin. At Milan, however, the pressure is varied according to a tabular rule when the current varies. The use of pilot wires is, however, very desirable, but I hold that hitherto the pilot wires have generally been placed in the wrong position. Suppose that a 4 per cent. variation exists over the district of mains supplied by any one feeder, and that the point where the feeder strikes the mains is kept at constant pressure, then the most distant lamp supplied by that feeder has a variation of 4 per cent. If, however, the pilot wire came from a point half-way between the most distant lamp and the feeder, and this point were kept at constant pressure, the maximum variation of pressure would be reduced to one-half, and would be only 2 per cent. It appears, then, that by properly placing the pilot wires the variations in pressure can be reduced to one-half; or, keeping the variations of pressure the same, the quantity of copper in the mains may be reduced to one-half.

In these suggestions as to dynamos at different pressures and as to the position of pilot wires I am supporting a course which has not been generally adopted anywhere, but the improvement ought only to be mentioned to receive general recognition.

Lamps of Different Voltage.

It has often been proposed to supply different parts of a district with lamps of a different voltage. In the ordinary plan of using feeders and pilot wires, the maximum pressure at the most distant lamp supplied by any feeder is the same as the pressure in the mains at the feeder. The minimum pressure may be, let us say, 4 volts less. Suppose 100-volt lamps are used, those near the feeder will always have 100 volts, but the most distant ones will have pressures varying from 96 to 100 volts. Ninety-six volts would make the lamps very dull; and if at the distant points lamps of 98 volts were used, the pressure would never vary more than 2 per cent. from the normal, and a better light would be obtained. This would be a very good arrangement if we could lay out a district from the beginning with all the positions of the lamps established, but it is found that as the station progresses a house which would have required 100 volts yesterday may require a limit of only 99 volts to-day, owing to the introduction of additional lamps between it and the feeder. Experiments which have been made in America on this plan have led to disastrous results and hopeless confusion in completing the scheme. This plan has been completely abandoned, and in the present state of the industry I think that this abandonment has been wise.

I do not think a greater variation of pressure than 2 per cent. up and down should ever be allowed if you wish to supply a satisfactory light.

I consider that success or failure of many electric light companies now doing central station work is very much dependent on their following or neglecting the proper rules for distribution, and I will illustrate the importance of these rules by a few examples.

1. A plain network by the two-wire system, fed at the central station with the economical size of copper conductors according to Sir William Thomson's law, say, of 1,000 amperes per square inch, and going to a distance of 480 yards, would have a difference of pressure to which the distant lamps would be subjected of 24 volts.

2. On the three-wire system this would be 12 volts with one-fourth extra copper.

3. With the same amount of copper as in the last, properly arranged with feeders, the feeding points being 160 yards apart, the maximum variation of pressure in any lamp over the district is two volts, if the pilot wires come from the feeding centres.

4. Everything remaining the same as this last, except that the pilot wires are placed in the proper position instead of at the feeding points, the maximum variation is only one volt.

Putting it in other words, the quantity of copper required to limit the variation of pressure over the district to a certain figure is in the last case one-twelfth part of what it is in the second case, and one-nineteenth part of what it is in the first case.

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High-Pressure Distribution.

Before I leave the question of distribution, let me now apply the same rules to the "Gaulard and Gibbs" system of using alternating currents with high pressure in the mains and low pressure in the houses, the reduction in pressure being effected by means of an induction apparatus called a "converter." At the present moment these converters are usually put in parallel upon the mains. There is a general impression in this country that it is not necessary to have feeders supplying the mains, even though the distance extends to several miles. Here again the experience of other countries has been set at defiance, although in a large town like London the importance of this rule is greater than in most American cities, or in Rome. If such views continue to be adopted, the result will be as disastrous in the future as it has been in the past. In the most extensive system in this country, when there is a large demand for current, the distant lamps look like red-hot hairpins, even though the near lamps be at full brightness. This is due to defective distribution.

As already stated, there is a general belief in this country that to whatever extent the Gaulard and Gibbs system is used no trouble comes from variations of electric pressure over the district, even when the converters are placed in parallel. Let us look at this question a little closer. Returning to the two-wire system for low pressure, if we use 1,000 amperes to the square inch as the economical section for our conductors, the fall in pressure is 5 volts for 100 yards; the loss of pressure due to the house wiring amounts very generally to 2 volts; hence the total variation between the periods of maximum and minimum output is 7 volts per 100 yards, or about double what is permissible (4 volts); hence, with the two-wire system such a size of conductor at 100 volts pressure could only be used for a distance of from 40 to 50 yards. Let us see how this distance is extended by using a pressure of 2,000 volts in the mains and 100 volts in the secondary. With the same density of current the loss of pressure in the house will be now 5 volts for 2,000 yards, to which must be added 2 volts for the house wiring and $1\frac{1}{2}$ volts for loss in the converter, making $8\frac{1}{2}$ volts loss of pressure in 2,000 yards.

If we allow 4 volts variation in the lamps, which is quite a maximum, this allows only $\frac{1}{2}$ per cent. variation in the mains, and then the greatest distance to which conductors can extend is 200 yards. The only means of extending the district is by the use of feeders. In America the practice prevails of allowing only $\frac{1}{2}$ per cent. loss of pressure in the mains. I have taken a concrete case of 1,000 amperes per square inch, which may not always apply to actual conditions, but it shows the necessity of adopting the universal foreign practice of employing feeders even with high-pressure mains.

Pressure Indicators on High-Tension Circuits.

It would be highly inconvenient to use pilot wires with the Gaulard and Gibbs system, such as are used on low-tension circuits; for this reason compound-wound voltmeters are used, which indicate the pressure at the far end of the feeder. I have described those in use at Rome and Milan; I have also described elsewhere those used by Westinghouse in America. The principle of these indicators is to have one winding connected like an ordinary voltmeter with the terminals of the dynamo, and another winding in reverse direction to carry the main current. The diminution in the indication owing to this second winding is always equal to the fall of pressure in the feeders. Different inventors have applied different classes of apparatus for accomplishing this result, but it is needless to say that the working out of such instruments takes a long time, more especially in such an instrument as that employed by the Westinghouse Company, which is made interchangeable for all circuits by the insertion of six different plugs, representing six different losses in the feeders, converters, and house wiring, varying from 3 per cent. to 10 per cent., besides four plugs for the different maximum currents in use with any feeder. I draw attention to this point because I consider that the successful working of such a central station depends largely upon the use of such an indicator of pressure; and I find manufacturers in this country who have had little or no experience in central station work prepared to equip central stations with all the necessary measuring instruments, and I wish to feel confident that these manufacturers have realised the importance of such instruments; and I wish earnestly to impress upon them, solely in their own interests, the necessity of working out such instruments if they wish to redeem electric lighting in the metropolis from the condition into which some of the so-called pioneers of this industry have reduced it.

Insulation.

We have now to consider a very important, and perhaps the most difficult, part of the problem of central station lighting—How are we to preserve our insulation? It must be noticed that we do not require a high insulation for the sake of getting a small loss of current, but only because with many insulators the high insulation is more permanent, and permanency is the quality of insulation which is most to be desired.

(*To be continued.*)

ELECTRO-HARMONIC SOCIETY.

The next smoking concert of the Electro-Harmonic Society will be an amateur night, and will be held on Friday, March 29, 1889, at the St. James's Hall Restaurant (Banquet Room), at eight o'clock. The following is a list of artistes: Messrs. M. G. Walters, T. H. Harrison, G. Glass, James Swinburne, M. Holroyd Smith, W. M. Foxcroft, A. H. Moore, J. E. Kingsbury, Aug. Dotzheimer, J. Perry, Ernest Renton, and the Brothers Greenop; accompanist, Mr. Alfred Izard; musical directors, Messrs. T. E. Gatehouse and Arthur Thompson. A Broadwood piano will be used. The following is the programme:

PART I.

Piano Solo ...."Gavotte."..........................Handel.
Mr. Alfred Izard.
Song ...."A tar of the Queen's."................M. Watson.
Mr. M. G. Walters.
Violin Solo ....“Andante tranquillo.”............Ch. de Beriot.
(From Seventh Concerto.)
Mr. Aug. Dotzheimer.
Song ...."The devout lover."........ Maude V. White.
Mr. T. H. Harrison.
Piano Solo ...."Romanze in F sharp."................Schumann.
Mr. James Swinburne.
Irish Song ...."Selected."...........................
Mr. G. Glass.
Recitation......"The heart of the Bruce," or Edinburgh after Flodden. Aytoun.
Mr. M. Holroyd Smith.
Five Experiments in Thought Reading ....
Messrs. Ernest Renton and G. Glass.

PART II.

Æolian Zitters.....................Selection............................
Messrs. Greenop Bros.
Song ...."At bay."..........................M. Watson.
Mr. T. H. Harrison.
Piano Solo ...."La Crepuscule."............ Wollenhaupt.
Mr. A. H. Moore.
Song..........................."The King's own."..........Th. Bonheur.
Mr. M. G. Walters.
Cornet Solo........................"Sérénade."........................ Gounod.
Mr. J. E. Kingsbury.
Recitation { (a) The slave's first hour of freedom. . Anon. (b) Selection from "His first champagne." } Lemon Reade.
Mr. W. M. Foxcroft.
Piccolo Solo......................"Selected."........................
Mr. J. Perry.
Banjo Selection..................."Selected."........................
Messrs. Glass and the Brothers Greenop.

COMPANIES' MEETINGS.

BRAZILIAN SUBMARINE TELEGRAPH COMPANY.

An extraordinary general meeting of this Company was held on Tuesday last at Winchester House, Old Broad-street, Viscount Monck in the chair, for the purpose of ratifying an agreement between the Company and the Western and Brazilian Telegraph Company, Limited, "with respect to the working of the lines of the two companies and the division of the traffic receipts thereof."

The **Chairman**, in proposing a resolution in accordance with the object of the meeting, observed that directors were constantly asked at such meetings as that to state minutely the way in which transactions respecting the company were carried on. Although there might be nothing whatever to conceal on its own account, yet he asked them, as business men, whether any private individual would carry on his transactions under such conditions. No one cared to admit that he was losing by his business, and on the other hand, if great gains were shown, it might have the effect, especially in such a business as theirs, of attracting competition, which would very likely interfere with their future profits. They could not communicate the nature of their transactions to the shareholders without taking the public into their confidence, and, that might be injurious to the Company's interests, although they might not have anything to say which was in itself at all disagreeable. The only way he saw out of the difficulty was to ask the shareholders to extend their confidence to the Directors, who had conducted their affairs for about sixteen years in a manner which, he ventured to say, had not been, on the whole, unsuccessful. The Western and Brazilian Company was started at the same time as their own Company; but while they themselves would in about four years hence lose their monopoly rights to the traffic to Brazil, the monopoly rights of the Western Company would last for 40 years longer. Of course, the termination of the concession would not prevent the Company from working to Brazil, but they would lose the monopoly. Hitherto the two companies had worked in intimate relationship, taking a certain proportion of each other's receipts, but it was now wanted to make the connection permanent and more intimate. Under the proposed agreement their future relations would be regulated by the receipts being paid into a joint purse, from which each company would take a certain proportion—namely, 54 in the case of the Brazilian Submarine Company, and 46 in the case of the Western Company. The agreement contained an article, to which he attached great importance, enabling them to allow the Brazilian Government to come into the arrangement, if they should wish to do so, on terms to be agreed upon.

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If that could be carried into effect, both companies would be placed in a very advantageous position, but the Brazilian Government had not as yet shown much wish to give its adhesion to the article. He hoped that the Government would in the future be better advised, and meantime the agreement would place the two companies on a very satisfactory basis for the future conduct of their trade.

Mr. Burt (the solicitor) then read the agreement, which is to take effect from the 1st inst., and under which the Western and Brazilian Company are to lay cables from Pernambuco to Bahia, from Bahia to Rio de Janeiro, and between Rio Grande do Sul and Montevideo.

Sir James Anderson seconded the resolution, which was agreed to.

WESTERN AND BRAZILIAN TELEGRAPH COMPANY.

An extraordinary general meeting of the Western and Brazilian Telegraph Company, Limited, was held on Tuesday last at Winchester House.

Mr. W. T. Andrews presided, and submitted a resolution for ratifying a working agreement between the Company and the Brazilian Submarine Telegraph Company, Limited.

Mr. Guesdon thought it unfair to call upon shareholders, at a few minutes' notice, to ratify an agreement on which Directors and solicitors had been engaged for several months. He suggested that the agreement should be printed.

The **Chairman**, in reply to questions, stated that the way in which the capital would be raised for the new cables which had to be laid by the terms of the agreement would be matter for another meeting. It was a well-known fact that certain telegraph concessions had been granted to other companies by the Brazilian Government, but most of those concessions were dead, and those that were not dead were dying. He could say nothing as to future concessions that might be made by the Brazilian Government; but the agreement before the meeting would consolidate matters so far as the lines of the two companies were concerned, and have a great influence in staving off competition.

The resolution was approved.

MONTEVIDEO TELEPHONE COMPANY, LIMITED.

At an extraordinary general meeting of this Company, held on Friday at the offices, Mr. Arthur Holland in the chair, the resolutions passed at the meeting held on the 27th of February as to the increase of the capital were duly confirmed, the increase being for the purpose of acquiring the business of the Gower-Bell Telephone Company, and thus consolidating the telephone business in Montevideo. At the conclusion of the meeting, the Chairman announced that an interim dividend at the rate of 6 per cent. to the 31st of December, 1888, would be paid on the preference shares on and after the 23rd inst.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the week ended March 15 amounted to £5,148.

West India and Panama Telegraph Company.—The traffic receipts of this Company for the half-month ended March 15 show an increase of £343 as compared with the corresponding period.

Western and Brazilian Telegraph Company.—The traffic receipts of this Company for the past week, after deducting the fifth of the gross earnings payable to the London Platino-Brazilian Company, were £4,074.

Eastern Telegraph Company, Limited.—This Company announce the payment on April 15 of a dividend of 3s. per share on the preference, less income-tax, for the quarter ending March 31, and an interim dividend of 2s. 6d. per share on the ordinary shares, tax free, in respect of profits for the quarter ended December 31.

Western Counties and South Wales Telephone Company, Limited.—The report for the year ending December 31 states that the capital expenditure was £27,885, making a total of £113,176 to date. The gross revenue was £32,206, against £23,597 for 1887. The amount of income carried forward to next year's revenue, as representing sums received in advance for periods extending beyond December 31, 1888, is £10,403, against £8,043. The working expenses were £8,337, against £6,693. After providing for the dividend of 6 per cent. on the paid-up preference share capital, the Directors recommend a dividend of half per cent. per annum on the ordinary shares, and that £200 be placed to the special reserve fund, carrying forward £1,246.

PROVISIONAL PATENTS, 1889.

MARCH 11.

4208. **The automatic regulation of E.M.F. or current in dynamo machines.** Herbert Tom Harris and Albert Gay, 27, Martin's-lane, Cannon-street, London.

4250. **Improvements in apparatus for attaching and suspending electric lamps.** James Ernest Spagnoletti and Joseph Crookes, 21, Cockspur-street, London.

MARCH 12.

4287. **Improvement in instruments for measuring electric currents.** John William King, 13, St. John's-square, Clerkenwell, London.

4296. **Improvement in galvanic batteries.** James Kynoch, 7, Bank-buildings, Church-street, Camberwell, London.

4336. **Improvements in electrical switches.** Thomas Spencer, 18, Warwick-street, Regent-street, Middlesex. (Harry T. Paiste, United States.) (Complete specification.)

MARCH 13.

4371. **Improvements in electricity meters, parts of such improvements being applicable to electrical clocks and other electrical instruments.** George Hookham, 7 and 8, New Bartholomew-street, Birmingham.

4407. **Improved method of and means for code signalling with electric telegraphs.** Henry Edward Montagu Dorrington Clotworthy Upton, 28, Southampton-buildings, Chancery-lane, London.

MARCH 14.

4448. **Improvements in or pertaining to incandescent electric lamps.** Francis Edward Elmore, Armaside, Cockermouth.

4484. **Improvements in electric distribution.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

MARCH 15.

4519. **Improvements in electric cranes and hoists.** Wilson Hartnell, Benson's-buildings, Park-row, Leeds.

4530. **Improvements in coin-freed apparatus for obtaining a current of electricity during definite periods of time for producing electric light, and for other purposes.** Henry Sherley Price and Herbert John Dowsing, 115, Cannon-street, London.

4559. **Improvements in voltaic batteries.** Desmond Gerald Fitzgerald, 47, Lincoln's-inn-fields, London.

4566. **An improved method of distributing electricity for lighting purposes.** William Llewellyn Preece and Josiah Sayers, 24, Glycena-road, Lavender Hill.

MARCH 16.

4586. **An electric light switch.** Alfred Milton, Howard William Bishop, and Frederick Brown, 4, The Bridge, Walsall.

4588. **A portable electric alarm clock.** Sam Naylor, 12, Corporation-street, Halifax.

4599. **Electrolytical process and apparatus for producing bleaching powder and other materials.** Charles Lever, 77, Chancery-lane, London.

4623. **An improved metal reflector for electric search lights used in ships of war.** John Farquharson, Pomona House, King's-road, Fulham, London.

4642. **Improvements in apparatus for measuring and registering the consumption of electric energy.** Ernest Auguste George Street, 45, Southampton-buildings, London.

4654. **Improvements in meters for electricity.** Jules Cauderay, 24, Southampton-buildings, London. (Complete specification.)

4656. **Improvements in electric signal apparatus.** Henry Thomlinson, 24, Southompton-buildings, London.

4657. **Improvements in electrical weighing machines.** James Murdoch Napier, 24, Southampton-buildings, London.

SPECIFICATIONS PUBLISHED.

1881.

1240. **Armatures for electric machines.** Brewer. (Second edition. 8d.

1888.

924. **Electric measuring apparatus.** Lorrain. 1s. 6d.

4568. **Electrical conductors.** Williams. 6d.

5201. **Coin-freed apparatus for electric light.** Davies and Tourtel. 11d.

8354. **Depolarizers for batteries.** Leclanché. 6d.

118. **Electric brakes for railway trains.** Widdifield and Bowman. 8d.

1103. **Electric lighting.** Lowrie and Hall. 6d.

1162. **Electric governors.** Kennedy. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	[illegible]
27 July	10/0	India Rubber, G. P. & Tel.	10	18½
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
26 April	4/0	Reuter's	8	7½
......	...	Swan United	3½	2¾
12 July	12/0	Telegraph Construction ...	12	41½
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15

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NOTES.

Finance and Electric Light.—The electric light is being put into the offices of Messrs. Rothschild in New-court.

The Paris Exhibition.—The Lord Mayor's Committee have decided to send a number of electrical engineers to the Paris Exhibition.

Society of Arts.—The second Cantor lecture by Mr. C. V. Boys, F.R.S., "On Instruments for the Measurement of Radiant Heat," will be delivered on Monday, April 1, at 8 p.m.

Electric Railway with Water-Power.—The electric railway, three miles long, to be erected at Negaunee, Michigan, will be worked by water-power, 10 miles away.

Edison Patents in Canada.—With reference to the recent decision, by which Edison's patents in Canada were declared void, the Edison Company of New York state they are intending to take the case to the Canadian Court of Appeals.

The Lighting of the City.—Particulars will be found elsewhere in our columns of a meeting of the Streets Committee of the Commissioners of Sewers to receive tenders for lighting the City of London by means of electricity.

Paris.—The Municipal Council of Paris have thought it well to extend the public lighting of the streets, on the occasion of the Exhibition, along the streets on the left bank of the Seine, and have asked for a grant of 50,000f. for this supplementary lighting.

Galway.—The Galway Electric Company will use Brockie-Pell arc lamps in carrying out the contract for lighting the docks for the Harbour Commissioners. The works of the company are driven by water-power, and are in close proximity to the docks.

Arragon.—Teruel, capital of the province of Arragon, Spain, is shortly to have a central lighting station, situated about a mile from the city. The power is to be obtained by a 40 h.p. turbine, and it has been decided to adopt the alternate current system with transformers.

Electric Automatic Boxes.—A company to work an automatic electrical box is being formed in Edinburgh, to which town the inventor belongs, to supply books, and ultimately newspapers, theatrical programmes, pipes, photographs, and other similar articles of daily want.

Tramways in India.—A tramway is proposed to carry the forest produce from Courg to Hunson in Mysore, India, and the scheme is under the consideration of the Government. A proposal of this kind is one in which it would be well to press the advantages of electrical traction.

A Question of Temperature.—*Practical Electricity* asks the following question: "If, when placed in a room of 50deg. F., normal temperature, a dynamo raises the temperature to 100deg. F., what would be the increase of temperature if the normal temperature were already 100deg. F." ?

Telegrams to the Far East.—The Indo-European Telegraph Company, Limited, state that the lines being now restored, they are prepared to accept messages for transmission between this country and India, Penang, Singapore, China, Java, Australia, New Zealand, Persia, Southern Russia, and Turkey.

Electric Railway Turn-Tables.—The Philadelphia and Reading Railroad, U.S., is having a "transfer table" constructed, for which the driving plant will be supplied by the Sprague Electric Motor Company. This is the third transfer table that this company has equipped. The first was put in at Aurora for the Chicago Railway, about nine months ago, and the second will soon be in operation at the Pennsylvania shops at Altoona.

The Woolwich Free Ferry.—On Saturday afternoon, this, the first free ferry established on the River Thames, was opened to the public. Each ferry-boat is 164ft. in length by 42ft. beam, and is furnished with two independent diagonal low-pressure engines of 700 h.p.; the object being to obtain propulsion from either or both of the ends. Steam steering-gear is fitted, and 72 incandescent lamps light the saloons, etc., of each vessel.

Telegraphy and Telephony.—The remarkable manner in which telegraphy and telephony have progressed in 1888 is shown by the following figures. The number of telegraph offices throughout the world has increased in 1888 by over 7,200; the 10,000th office, says *Kuhlow's Gazette*, was opened in Germany during last year. Telephones have also undergone a similarly great extension. At present there are 750 in the United States with 200,000 subscribers. In Germany there are 174 telephones and 32,920 subscribers.

Personal.—Messrs. Mather and Platt, of Salford Iron Works, Manchester, have opened a London office at No. 16, Victoria-street, Westminster, which will be under the charge of Mr. Hardman A. Earle, who has for some years been the assistant-manager of their electrical department. Mr. A. Blackburn, Assoc.Mem.Inst.C.E., has resigned the position which he has held for some years as resident engineer to the Edison and Swan Company, and has joined the staff of Messrs. Mather and Platt's electrical department as assistant-manager.

Birmingham Exhibition.—Lithographed plans, showing the sections and available spaces at the Electrical and Industrial Exhibition at Bingley Hall, are ready to be supplied to proposing exhibitors by the Executive Committee at the County Chambers, Birmingham. As the exhibition will be the opportunity for display of the latest applications of electricity to daily life, and for actual exhibition in operation of electricity as applied to all manners and kinds of manufacturing, it will be well for electrical engineers and inventors to take early pains to render their exhibits as interesting as possible from this point of view.

Elieson Electric Company.—We have received from Messrs. Kirk, Price, and Goulty an illustrated catalogue of the articles to be sold by public auction on April 17. It is unnecessary here to enter into the history of the company, the whole of the property now coming under the hammer, as well as all the British, foreign, and colonial patents. The plant and machinery consist of a Marshall and Co.'s engine, one of their local type with tubular boilers, and a Richmond engine, a quantity of shafting, a number of dynamos, lathes, mechanics' tools, fittings and appliances for workshops, a number of motor cars and gearing, and an Elieson accumulator. The number of lots, including office fittings, is over 350.

Tenders for Zurich.—Zurich is to be lighted by electric light, by means of water power, with a plant of the capacity of 650,000 watts. The contract is open to tender from Swiss or other electrical engineers, the tenders to be

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sent in before the 15th May next. The power will be supplied by the town water works, which are to be extended and supplemented with steam engines in reserve for a capacity of 750 h.p. This is equal to about 450,000 watts. When both water and steam are working together, with both arc and incandescent circuits, the capacity will correspond to the above total of 650,000 watts. Forms of tender, with plans and sections of the water power works, are to be obtained of the Bureau de la Ingenieur de la Ville, Zurich, who will furnish all other particulars.

The Proposed New Submarine Cable.—In the House of Commons, on the 21st inst., Sir E. Watkin asked the Postmaster-General whether any steps had yet been taken or decided upon in reference to laying a submarine cable between the British Atlantic fortress of Bermuda and the British fortress of Halifax; and whether it was intended to restore direct postal communication by British ships between Halifax and Bermuda; and, if not, in either or both cases, what were the reasons. In reply, Mr. Raikes stated that the Government have decided to lay a cable from Halifax to Bermuda. The Legislature of Jamaica had agreed to grant a subsidy to a line of steamers running between Halifax and Kingston, and calling regularly at Turk's Island and Bermuda. He understood that the service commenced last October.

Dover Industries.—Under the above title the *Dover Express* comments upon the work of Mr. Alfred Crofts, of Dover, who has written a *brochure* on "How to make a dynamo," and also arranged to supply amateurs with small castings, etc., for dynamo making. Our contemporary, with delightful freshness, describes a visit to Mr. Crofts' workshop. We are told how "electricity was encountered in the door-bell"; how "when a whisper of the telephone came over from America, Mr. Crofts got hold of the secret before it was practically applied in this country"; and, finally, how the dynamo is "built bone to bone and sinew to sinew." "Thus," concludes our contemporary, "Dover has been made a centre to which amateurs all over the civilised world turn for help and counsel in producing the light of modern days."

Electricity and Lifeboat Work.—Speaking at the sixty-fifth annual general meeting of the Royal National Lifeboat Institution, on Saturday last, Lord Charles Beresford said that if there was quicker communication between the stations a boat would often go out under more favourable circumstances. The question of quickness of communication round the coast deserved the attention of the whole nation, not only from the point of view of lifeboat work, but also of defence of the country. Between the lighthouses, lifeboat stations, and coastguard there should be better means of communication, and also with the head of the Intelligence Department at the Admiralty. A great many more lives would have been saved had there been electric wire communication throughout, and it was his intention to again bring the matter before the House of Commons.

A Miniature Battery.—Numerical quotations from electrical professors do not demonstrate the extreme smallness of the electric current which suffice to affect a telephone so well as an actual demonstration. Mr. J. H. Farnham, having to lecture before a New York audience, recently showed a miniature battery, to illustrate the minuteness of telephone currents. This consisted simply of a glass bead, through which was threaded a thin copper wire and a thin iron wire, the ends being connected to a telephone line. The solution was one drop of acidulated water. By means of this battery, signals were transmitted over more than 200 miles of wire. To a popular audience this is a wonderful experiment, and is, indeed, a striking illustration of the sensibility of the telephone. A drop of water containing sal ammoniac may be used instead of the acidulated water.

The Lighting at Taunton.—Since the adoption of the electric light for the main streets, Taunton has been visited by deputations from all parts of the United Kingdom. On Monday last, a sub-committee of the Bedford Town Council, appointed for the purpose of considering electric lighting, went to Taunton to see if the reported success of the electric lighting of the streets was a virtual fact. The gentlemen were conducted to the central station of the Taunton Electric Lighting Company by Mr. J. H. Smith, the surveyor, and were met at the works by Mr. O. V. Thomas, the electrician in charge. The deputation returned to Bedford on Tuesday morning with the unanimous opinion that they had never seen a better system of street illumination. On Tuesday, Taunton was again visited by a deputation appointed to obtain particulars and notice the effect of the electric street lighting. This deputation was from the Chelmsford Town Council, which is now considering the question of a better illuminant than gas for public purposes.

The Indian Telegraph Department.—In the House of Commons, on Monday last, Sir J. Gorst, in answer to Mr. D. Sullivan, said the dates for making promotions in the Telegraph Department were fixed by the Government of India, and the Secretary of State is not disposed to interfere in the matter. Mr. D. Sullivan asked the Under-Secretary for India how many officers of the Telegraph Department had more than 30 years' service; and if, in the interests of the public service, whether as regards the efficiency of the department or economy in the matter of pensions, he would consider the advisability of retiring those officers, many of whom had already been superseded by officers many years their juniors, on special pensions, rather than allow men in the prime of life, and who were specially trained for the department under the reorganisation scheme of 1886, to leave the service in disgust. Sir J. Gorst replied that the number of such officers was ten. With regard to the second enquiry, the Secretary of State saw no necessity for altering the rules as to the retirement of officers in the Telegraph Department.

The British Association.—The list of officials for the coming meeting of the British Association at Newcastle-on-Tyne has been arranged. The president will be Prof. W. H. Flower, F.R.S., Director of the Natural History Museum. The presidents of the various sections are as follows: A. Mathematical and Physical Science, Captain W. de W. Abney, R.E., C.B., F.R.S. B. Chemical Science, Sir I. Lowthian Bell, F.R.S. C. Geology, Prof. James Geikie, LL.D., F.R.S. D. Biology, Prof. J. S. Burdon Sanderson, M.A., M.D., LL.D., F.R.S. E. Geography, Colonel Sir Francis de Winton, K.C.M.G., F.R.G.S. F. Economic Science and Statistics, Prof. F. Y. Edgeworth, M.A., F.S.S. G. Mechanical Science, William Anderson, M.I.C.E. H. Anthropology, Prof. Sir W. Turner, LL.D., F.R.S. The first general meeting will be held on Wednesday, September 11, at 8 p.m. On Thursday evening, September 12, there will be a *soirée*; on Friday evening, September 13, a discourse on "The Hardening and Tempering of Steel," by Prof. Roberts-Austen, F.R.S.; on

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Monday evening, September 16, another discourse; and on Tuesday evening, September 17, a *soirée*.

The Chemical Society.—The president of this society, William Crookes, F.R.S., last night delivered his inaugural address, which was on "Recent Researches on the Rare Earths as interpreted by the Spectroscope." Mr. Crookes' unique ability in this direction is known to our readers, and this address is a natural continuation of that given at the British Association. It contains nothing directly pertinent to electrical matters, though any researches which give us a fuller acquaintance with molecular physics must lead us nearer to the time and the point when we can say "this is electricity." The concluding sentences of Mr. Crookes' address may be given: If the study of the rare earths leads us to clearer views on the nature of the elements, neither my colleagues nor myself will, I am sure, regret the months spent in tedious and apparently wearisome fractionations. No one can be more conscious than myself how much ground is yet uncovered, and how many radical questions have received but very inadequate answers. But we can only work on, "unresting, unhasting," trusting that in the end our work will throw some white light upon this deeply interesting department of chemical physics.

Duties on Electric Machinery to France.—The Board of Trade have kindly communicated the following memorandum, based on the latest information in the possession of the department, for circulation to the members of the Electrical and Allied Trades Section of the London Chamber of Commerce, showing the duties levied by France on: 1. Dynamo-electric machines—(*a*) if weighing less than 30 kilos. (66lbs.), these are admitted free of duty on the same footing as "scientific instruments"; (*b*) if weighing 30 kilos., or more, they are charged with duty as "machinery unenumerated," the duties upon which category, are, containing 75 per cent. or more of cast iron per 100 kilos., 6f.; from 50 per cent. to 75 per cent., 10f.; less than 50 per cent., 15f. 2. Electric lamps—accessories of electric lighting, such as switches, regulators, arc lamps, etc., are chargeable as manufactures of metal according to class, the duty upon such as are of copper, or of copper mixed with zinc or tin, being at the rate of 20f. per 100 kilos. Incandescent lamps of blown glass are chargeable as "articles of glass not otherwise mentioned," the import duty under this head 18f. 50c. per 100 kilos. Accumulators are charged according to the metal of which they are composed.

The French Telephone Service.—Advices from Paris state that the Government has just introduced a Bill with the object of repurchasing the concession granted to the Telephone Company. Since 1879 the telephonic networks of Paris and of nine provincial towns have been worked by the company. The concession which was granted in 1879 for five years was renewed in 1884 for another period of five years, which will expire on September 8 next. The Bill proposes that the State shall purchase the company's stock of materials, and conduct the work itself. The necessary funds will be raised by the Deposit and Consignment Office. The purpose of the Government is to reduce the rates of subscription to the telephone. The second part of the scheme relates to towns which are not yet in possession of a telephonic system. The State will require towns wishing to have telephonic lines introduced to advance the funds necessary for the opening of the network, and will repay the advances by a deduction from the receipts. When the repayment has been completed, the State will take possession of the lines so constructed and work them. The town of Limoges has already entered into a contract of this kind with the State, and a Bill has been adopted confirming it. Twenty other towns having applied for similar contracts, the Government resolved to introduce the present general Bill.

The Submarine Cables.—It is stated that the price offered by the Government for the French and Belgian cables of the Submarine Telegraph Company, together with the instruments and stores, is in round figures £35,000. No offer has yet been made for the company's cable ship, buildings, and other property, the necessary valuations not having been yet completed. The cables were all valued and tested by electrical engineers appointed by the British, French, and Belgian Governments. It may be mentioned in this connection that the Belgian cables were valued proportionately higher than the French. The Post Office authorities have practically completed their arrangements for beginning the Continental work on and after the 1st of April. Officials from St. Martin's-le-Grand have been at the Submarine Company's offices almost daily. Their first care will be to overhaul the existing cables and put them in good working order. In the course of the coming summer a new cable of four wires now in the course of manufacture will be laid to France, and others will be put down as they may be required. It is also stated that on and after April 1 Liverpool will enjoy the advantages of direct telegraphic communication with the important commercial centres of Havre and Hamburg. An extraordinary meeting of the proprietors of the Submarine Telegraph Company was summoned on the 25th inst. Particulars of this meeting will be found elsewhere in our columns.

Welding by Electricity.—At the central station of the Malden Electric Company of Malden, Massachusetts, on Monday evening, the 4th instant, a successful exhibition of electric welding was given by the Thomson Electric Welding Company, of Boston and Lynn. The tests were made for the inspection of representatives of the press. Some fourteen tests in all were made, and were all successful, says the *Western Electrician*, the time for the operations ranging from a few seconds to one minute and forty seconds. Brass, copper, and iron bars of small diameter, $\frac{1}{4}$th, $\frac{5}{16}$th, $\frac{3}{8}$th, and $\frac{1}{2}$in. were first manipulated after being properly clamped. Then came the tests with larger bars; still later the joining of an extra heavy 2in. iron pipe, and, finally, round iron rods of 2in. diameter were welded. Three transformers, each of which could be put instantaneously into connection with the dynamo, were used, the selection of any individual one by the operator depending upon the size of the metal to be welded. When one of the induction-coils was in service the others were, of course, not in the circuit. After the welding of the smaller pieces of metal they were twisted until they broke, but the break in no instance occurred where the joint had been made, and what one operator had joined, others, even with the aid of mechanical devices, failed to pull apart. The tests were made by Russell Robb, under the direction of Hermann Lemp, the electrician of the company; John Tregoning, the superintendent of the factory at Lynn, was also present, as was Otis K. Stuart, who has charge of the specimen welding. No unions of dissimilar metals were made, but these can be effected easily, and the adaptability of the invention to both small and large work is particularly to be noticed. The invention is doubtless destined to be commercially successful.

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The Electric Motor in Engineering.—We mentioned last week the employment of an electric motor for working a drawbridge over the river at Bridgeport, Conn., U.S. The attention of engineers of all countries who have to deal with the moving of bridges, cranes, etc., where steam is now generally used, might well be given to the extended application of the light and powerful motor to this purpose. The *Chicago Herald*, commenting upon the new application, makes the following sensible remarks: "It would be an excellent idea if the city engineer should include electricity in his calculations with reference to the turning of bridges hereafter to be built. With steam, the weight of the structure is very largely increased by the boilers and water, as well as other cumbersome appliances. There must now be a steam-engine and boiler for each bridge. In case electricity were used it could be generated at some central point and carried by wires to the various bridges. The bridges could, with only the additional weight of an electric motor, be made much lighter than they are at present. This would be a substantial economy in the cost of construction, which would lighten materially the expense of bridge building. In truth, the time is not far distant when the electric motor will be an economical substitute for the great majority of engines now operated by steam. The latter are stiff and unyielding, generating unendurable heat in summer, and must have all their parts near where the work is done. Each building using power must have its boiler and engine in the basement, and it is often the case that steampipes have to be led to other floors of the building for the conveyance of power, or else the work has to be transferred by belts, causing material loss by expensive friction. It cannot be long before electricity will supplant steam-power, as it now is doing with gas. The difference between gaslights and the electric lamp is no greater than is the width between steam and electric motors. The latter are in every respect better, and, what is more convincing than all else, they are much cheaper."

Disruptive Discharges in Lead Cables.—A paper was read recently before the Chicago Electric Light Convention by Mr. C. H. Rudd, in which he attacks the conclusions of Mr. E. G. Acheson, that failures in high-tension cables were due to the static charge. It is evident, he maintains, that we have nothing as yet to indicate that the arc makes distinction between the static charge in motion and other electricity in motion. It is also evident that the insulation of a cable does not undergo strain at shutting down due to static charge. After discussing Mr. Acheson's experiments, and giving others of his own, he says, in conclusion: "If disruptive discharges occur in properly insulated cables, we must look for the cause in those sources of high pressure which exist in nature. I do not believe that burn-outs can be ascribed to any one cause, but that each individual case has its own individual cause. In practice we must provide insulation strong enough to meet the daily strain, and suitable devices to prevent the accumulation of charge from outside sources of greater pressure than the insulation will bear. As yet we have no proof that high-pressure protectors are required anywhere outside of station from which the wires start. Mr. Acheson says that the greater number of grounds or burn-outs occurring on arc light circuits are at the terminals of the lead or at the joints, and says that such a state of things would be naturally caused by the greater density of the static charge at these points. This statement strikes me as a singular carrying over of ideas obtained in laboratory work with purely static electricity and arbitrarily applying them to entirely different conditions. The natural static charge in a cable, due to the distribution of the working E.M.F. of the current in the cable, must necessarily be governed in its distribution by the force from which it originated. The shape of the conductor cannot act in the matter of this kind of static distribution, as the shape of an insulated conductor would act upon a purely static charge. This remark of mine about distribution may not be treated of by any of the men who write books, but I confidently appeal to my hearers for support. As regards burn-outs occurring at terminals and joints, we know that great care is required to make these points equal to the rest of the cable in a matter of insulation. I do not see how it can be known that burn-outs at such places are not due to accident in construction or actual neglect on the part of the workmen."

Extension of the Richmond (U.S.) Electric Road.—The electric railway at Richmond, Virginia, writes a correspondent of the *Electrical World*, has evidently given satisfaction, for it is to be considerably extended at once. In fact, the company is now at work making the alterations necessary to change about 12 miles of road from a horse—or, to be more exact, a mule—car line to an electric road. This will just about double the present length of track. The number of electric cars will also be doubled. There are now 40 or 50 more to be added. It is thought that the changes will be completed in about a month, and then the Virginia Electric Light and Power Company, which operates the road, hopes to give the Richmondites even better satisfaction and more efficient service than it has had heretofore. It is only fair tot he company and to the cause of electric railways in general to say, however, that to the enquiries I made among those in no way connected with the electrical business, I got but one reply: "The electric road is a great success, and has given a wonderful impetus to the growth and development of the city." Everybody seems to take a laudable pride in it, and everywhere along the line of the road houses are going up, which shows how quick the citizens are to take advantage of the facilities it offers for rapid and comfortable transit between their offices and homes. Superintendent Trafford tells me that everything about the road and its electrical features runs along smoothly and pleasantly. A trip over the road, such as I made to-day in company with Mr. M. B. Leonard, cannot but convince anyone of this fact; and it is a long ride for five cents. I was much pleased with the neat, tidy, and business-like appearance of the power station, which, I ought to mention, also furnishes current for about 4,000 Westinghouse incandescent lights, as well as some 40 commercial motors—Sprague, Daft, Baxter, etc. In addition to this, the company, from another station, runs 300 Schuyler arc lights. It gets a very fair rate for the motor service—125dols. (£26) for the first horse-power and 100dols. (£20. 16s.) for each additional horse-power. The equipment of the station includes at present six No. 16 and one No. 20 Edison machines, one 2,600-light and one 650-light Westinghouse machines. The engines consist of three Armington and Sims of 125 h.p. each, two Westinghouse of 65 h.p. each, one Westinghouse compound of 250 h.p., and one Ide of 150 h.p. Another Armington and Sims engine will be put in when the changes in the road are finished, to run two more No. 20 Edison machines. An additional 2,600-light Westinghouse dynamo has also been ordered, to enable the company to meet the increasing demands upon it in this department of its business.

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THE ELECTRIC SEWAGE WORKS AT CROSSNESS.

"To what base uses may we return!" is tempted to exclaim the electrical engineer when he hears of the application of the force he deals in to—not now light and beauty and swift travel—but to the treatment of sewage. Yes, and to what beneficent and healthful uses, he may well add, in consonance with the sanitary engineer, as it is proved to him that the same current that would electroplate the teapots and spoons in Sheffield alters with its magic touch the most vile and deadly matter, now poured by millions of gallons daily into our rivers, into a pure liquid—and not only into pure water, but into an absolute disinfectant. Such is, indeed, the fact; and the science of health—the coming science of the future—will have at its hand the aid of electricity to settle the enormous difficulty it has hitherto had to contend with in the disposal of the sewage of its large towns; and an engine and a dynamo will become the modern Hercules which will purge the Augean stables of our metropolis.

With this preamble upon the imaginative and prospective side of what is at best a somewhat unsavoury subject, foreign to the consideration of electricians in general, we will describe this, the most recent of the applications of electricity to the problems of civilisation, a far-reaching field of usefulness which may extend throughout the world wherever cities grow up.

The system of the electrical treatment of sewage has been explained by Mr. William Webster, the inventor, before the Sanitary Association, in 1888, when some lecture experiments were shown to illustrate the process. The paper was given at that time in the *Electrical Engineer* (see vol. II., p. 178), but the system has never been shown publicly on a practical scale until this week, on Wednesday last, when a number of gentlemen connected with the technical and daily press were invited to see the experimental works which have been constructed at Crossness. These works have been erected by Mr. Webster, under authority from the late Metropolitan Board of Works, at his own expense, to demonstrate the utility of the invention, and some 12,000 gallons of sewage per hour can be here treated, the solid matter precipitated into sludge, and the effluent water drawn off, and discharged into the river.

The Sewage and Works.

It may, perhaps, conduce to the better understanding of the process and its application if we briefly describe the present system of the disposal of the sewage of London. There are at present two main outflows—one for the districts north and the other for those south of the Thames—the first at Barking, and the latter at Crossness, 1½ miles from Abbey Wood Station. It is at this latter outflow that the experimental works of Mr. Webster have been carried out. It is a mistake to suppose that the sewage, as dealt with at these stations, is horribly repulsive and offensive to sight and smell. It is simply a dark-looking fluid, quite liquid, certainly with a scum on its surface, and a slight odour of sewer gas, but in appearance not very much worse than the ordinary streams of many manufacturing towns. This volume of impure liquid comes down a huge sewer of 11ft. 6in. diameter, and at the outflow stations is pumped direct into the River Thames without further treatment. The pumping station at Crossness is a handsome Gothic building of red and yellow bricks, with boiler-house very conveniently arranged—the coal trucks on rails, with door and platform, so that the firemen can fire direct from them. The engine-house contains several huge beam engines of the old type, now some 23 years old, but working very well, with high efficiency, and pumping an average of about 80,000,000 gallons a day, more or less, according to the rainfall over London. In some towns the rainfall is kept distinct from the sewage, but in London the rain is all drained into the sewers. The sewerage thus varies in strength, often changing from a pale amber to a dark purple in a short period. Those wishing to understand the working of the new system should note both the fact of the rainfall draining into the sewers in London and the continual change of strength.

The continual pouring of this 160,000,000 gallons (at the two pumping stations) of untreated sewage in the river is a most barbarous and dangerous method of dealing with the drainage of London. This has been well recognised by the authorities, and the Metropolitan Board of Works have had allowed them by the Special Commission a sum not exceeding £200,000 a year for the purpose of establishing means of precipitating and purifying the sewage at the outflows. Experiments of considerable extent have been carried out to deal with this question by chemical means, and quite recently some £30,000 have been spent in chemical precipitation. The chemical method is at work in several towns in England, but is unsatisfactory for several reasons: one is the great expense for chemicals; another is the actual labour in mixing; moreover, the precipitation accomplished, the effluent has still to be oxidised or purified, and the addition of chemicals to the water still tends to a prejudicial effect by reason of its alkalinity.

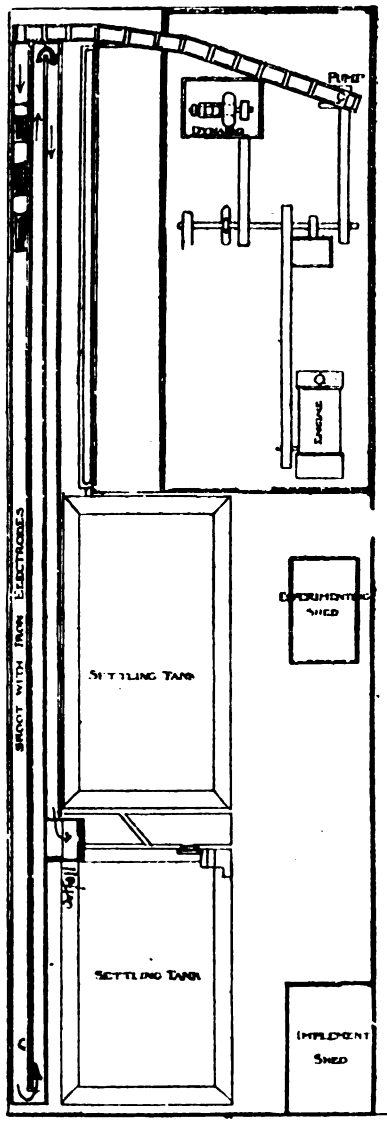

Fig. 1.—Plan of Electric Sewage Works at Crossness.

These defects are entirely overcome by the electrical system of treatment. The cost, as far as can be judged, is much less. The expense of chemical treatment is not accurately known, but varies in different towns from 30s. to 70s. per 1,000,000 gallons, whereas Mr. Webster calculates that the electrical system will cost only 13s. per 1,000,000 gallons for the actual cost of working, not including interest and depreciation, or including this, which will vary according to the make of engine and machinery, say, not over 20s. per 1,000,000 gallons. Mr. Webster, therefore, calculates that for the actual cost of working, the amount for purifying the total London sewage will be about £36,000 a year. When it is remarked that the authorities have been considering the expenditure of over £100,000 a year for this purpose by chemical means, the saving of the electrical process can be seen at once Even calling it £50,000 or £60,000 a year, this would be

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one-half the expenditure proposed, and even cost for cost a better effect would be produced by the electrical process.

The Principle of the Electrical Treatment.

Mr. Webster has been working in connection with sewage and water treatment most of his life, and was for some time a pupil of the late Dr. Letheby, who in 1857 recommended the Metropolitan Board of Works to try the lime process or the sulphate of iron process for precipitating the sewage. Mr. Webster conceived the idea that the precipitation might be brought about by electrolysis, and made some experiments to carry out this process with carbon plates; but it was not until about three years ago that the idea of using iron plates as electrodes, which has made the process a success, occurred to him.

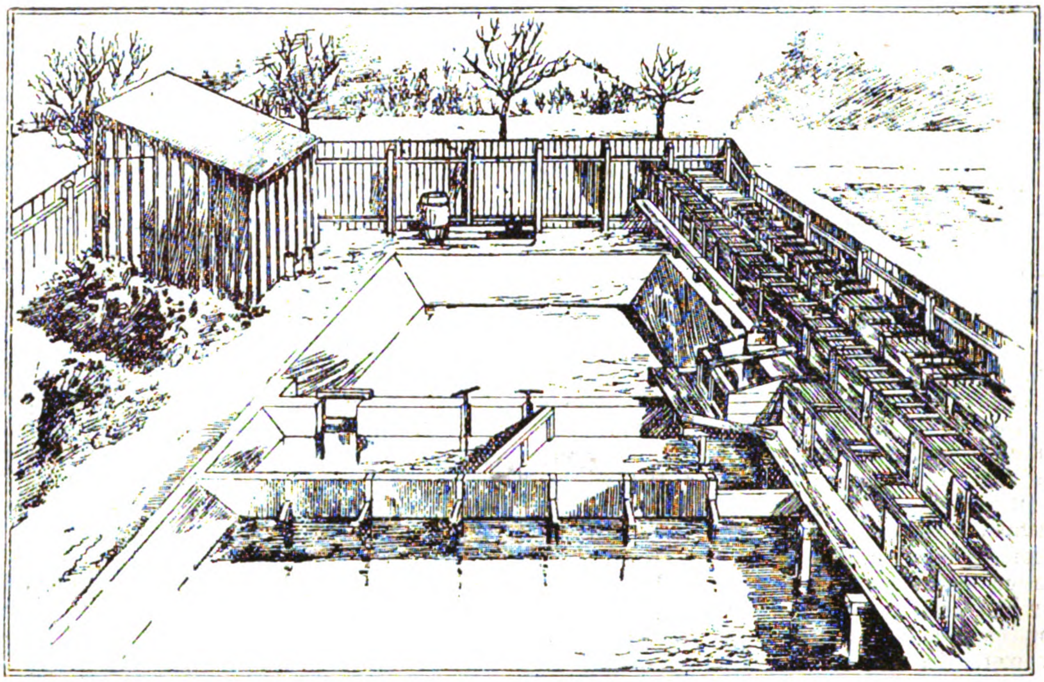

Fig. 2.—View of the Shoots.

On Wednesday, Mr. Webster showed some experiments with test-glasses of sewage, heated by electrolysis, with iron electrodes, to illustrate the action which takes place in his system. Several tall glasses were filled with sewage of varying strength, taken from the pumping station the day before. Wires were led from the dynamo to a pair of electrodes, which consisted of three long strips of iron on a wood frame; and when this simple arrangement was placed in the vessel and twisted about ebullition at once commenced, the matter in suspension became flocculent and rose in a scum to the top. In a few minutes the absolutely black and opaque liquid became variegated, the particles became detached, and shortly the liquid became more or less clear, with the solid matter separated. The scum and solid matter rises at first with the ebullition of hydrogen to the top, but afterwards subsides, and the effluent can be run off. The reaction is supposed to be as follows: At the positive pole nascent chloride and oxygen are given off, forming hypo-chlorite of iron. This hypo-chlorite of iron is precipitated by the ammonia, soda, etc., at the negative pole, and forms hydrated ferrous oxide. This particular oxide has the property of combining with organic matter, and flocculent particles are formed, which carry away the whole of the matter in suspension. The organic matter in solution is oxidised, and with proper care the water may be drawn off perfectly pure and bright. That the matter in solution is precipitated, was shown by the action of the same current upon a tube of water tinted with an aniline dye, the colour of which was rapidly taken out by the action. The effluent water, as a rule, is not only purified, but has actually gone to the other side, and remains a disinfectant. The effect of the bleaching quality of the sewage after treating was illustrated in another experiment: the characteristic smell of chlorine could be distinctly smelt upon shaking the specimen, and a little added to a glass of water which had been tinted with indigo rapidly took out the colour, showing the bleaching effect of the treated sewage.

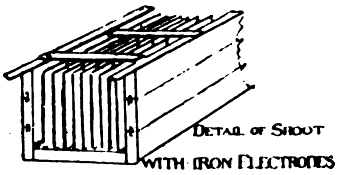

Fig. 3.

The Method in Practice.

At first the method adopted was similar to that of the test-tubes on a much larger scale. Huge tanks were erected, and plates of iron were connected and placed in these tanks; the whole quantity of sewage was heated and then drawn off to settle while a second lot was run into the tanks. It was found, however, that a continual motion of the electrodes was required to get sufficient contact with the liquid, and it was decided to abandon the tank system and adopt the method of having the liquid in motion instead of the plates.

The system now at work at Crossness is illustrated in the accompanying figures, Fig. 1 being plan of the works. It consists, in effect, of a long shoot doubled twice upon itself, down which the sewage gently flows after having been pumped up by the pump at one end (see view of the shoots, Fig. 2). All along this shoot are placed the electrodes in groups of 15 plates each. The arrangement of the plates on the shoot is shown in Fig. 3, the plates lying along the direction of the current. There are 22 sets of 15 plates each in parallel, and six such sets in series. The electrical pressure across the electrodes is 2·8 volts; the total pressure is therefore six times this, and, allowing a certain loss in the leads, makes the pressure at the dynamo to be 20 volts. The manner of connection between the sets in series is illustrated by the diagram, Fig. 4. The shoot is of wood, but in any permanent work it would be of brick, concrete, or iron, and the bottom would be lined with asphalte or other suitable material. The plates at present are of wrought iron, but for ordinary work would be cast out of ordinary pig iron.

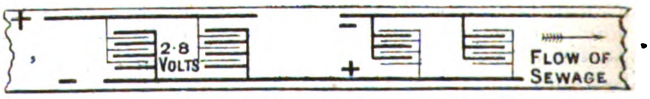

Fig. 4.—Diagram of Electrical Connections.

The sewage as it comes in flows along the upper shoot

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and back again twice, all the while passing between the electrodes ; every particle comes in contact with the plates and becomes electrolysised. By the time it has got to the outfall, a few minutes only, it is sufficiently treated ; it is run into one or other of the settling tanks and allowed to settle for an hour, perhaps two, and the effluent is then run off into the river. Such is Mr. Webster's system of electrical treatment of sewage, a simple and eminently scientific method, which cannot fail to entirely revolutionise the systems of town disposal of sewage.

THE DYNAMO HOUSE.

The dynamo used is an Edison-Hopkinson, working at a pressure of 20 volts, and capable of developing an energy of 43 h.p. The whole of the current is not at present utilised, about 500 amperes being the quantity now employed. The dynamo is driven, by means of counter-shafting, by an engine of old type, made some 25 years ago, of 20 h.p.

The speed of the dynamo is regulated by a Rung's pneumatic speed indicator, connected with the dynamo, but placed beside the engine-driver. The regulation of the strength of current for the different qualities of sewage is very simple. All that is required is to keep the voltmeter at 2·8 volts across the electrodes. If the rain falls, the voltmeter immediately goes up to 3 volts or over by increase of resistance, and the speed of the dynamo is then lowered to give the usual pressure.

POWER REQUIRED.

The experiments at Crossness have proved that with 27 h.p. it is possible to treat 1,000,000 gallons of sewage in 24 hours. These figures relate to London sewage, where the rainfall is mixed with the sewage. For towns where the rainfall is distinct, less power would be required, for the stronger the sewage in chlorides, etc., the less the electrical resistance.

As to the cost of the engine power, we need hardly state that the newest type of engines suitable for driving dynamos may be taken to consume two pounds of coal per h.p. hour, and according to the price of the coal will be the working cost. The experiments carried out with reference to the amount of iron consumed by this process tend to prove that the consumption in continuous working should not be more than two grains per gallon. Here, again, the cost entirely depends upon the district in which the works are situated, with regard to the price of pig iron. The plates are 1in. thick, and if used in sufficient numbers would last for many years when once fixed. For instance, a town with a flow of ten million gallons of sewage per day, corresponding to a population of 333,000 at 30 gallons per head, will require to treat this amount of sewage a consumption of iron not exceeding 464 tons per annum. On calculating the amount of mechanical power required per head of the population, Mr. Webster finds it represents $\frac{1}{1225}$ of a h.p., or 8 h.p. per 10,000.

It will be seen that the above plant is practically in lieu of the mixing-tanks, machinery, and chemicals employed in chemical processes for the treatment of sewage, and if such electrical plant is designed to meet the peculiar requirements of any particular district it should cost much less and have a greater efficiency than any other process known, for not only does this electrical method precipitate the matters in suspension, but it also removes organic matter in solution, and forms a precipitating and disinfecting process in one operation.

THE SYSTEM IN PRACTICE.

The present works—where the system is shown in operation at the rate of 12,000 gallons per hour—have cost Mr. Webster some £5,000 to erect and carry on, and in the work of experimenting and arrangement of the station he has been ably assisted by Mr. March, his assistant electrician. In carrying the system into practice, Mr. Webster does not intend to carry out the work himself, having already as large a business as contractor as he is able to conveniently manage, and he is now building the precipitating tanks at Crossness which will be used whichever system, chemical or electrical, is ultimately adopted. Mr. Webster has carried the system to a practical point, and wishes rather to arrange with sanitary or electrical engineers or town authorities to work his system under a royalty.

The average of 20 analyses taken at Crossness during 1888-9 show that of raw sewage, very turbid and opalescent, containing 33·35 parts of suspended matter in 100,000, the effluent was clear, containing 1·56 parts per 100,000.

SETTLING TANK.

The visitors on Wednesday were shown a new settling tank invented by Mr. Houghton, son of the engineer to the sewage works, which is extremely ingenious and simple, not necessarily part of the electrical treatment, but which will probably be employed in the new precipitation, etc., works at Crossness. One side of the tank is composed of a series of shutters like venetian blinds, which fall outwards, one after the other, to let the water out. A float behind the shutters, rising as the water rises, closes the shutters, each locking the one below. When the tank is full, after being left to settle, the water begins to flow over the top shutter, the float falls, and the shutters open one after the other downwards, drawing the water off the top always, and allowing the sediment to remain without disturbance from currents.

CORRESPONDENCE.

ELECTRIC LIGHT CIRCUITS.

TO THE EDITOR OF THE ELECTRICAL ENGINEER.

SIR,—I have read Mr. Fish's paper in your last issue with much interest, but I find it impossible not to take exception to his first conclusion, as to the standard of insulation to be adopted in order to obtain immunity from danger to human life. I object to it principally for two reasons : (1) that R is a variable and not a fixed resistance, and (2) the value of C as a death-dealing factor is not known with sufficient accuracy. Mr. Fish having obtained 4,000ω to 15,000ω as the hand-to-hand resistance of several persons, takes a somewhat curious mean of 5,000ω—a hard and fast mean, be it observed—and proceeds to calculate the value of C in each case, assuming E and R to be fixed quantities. Now this appears to me to possess the solidity and safety of the house built upon a quicksand : it's all right, so long as nothing comes along to disturb it. The mean of 5,000ω is, all things considered, a rather low value to take as the normal hand-to-hand resistance of the body *when the hands are dry*. My own tests are higher ; but it is also a fact that if the hands are moist—if the high skin resistance is partially neutralised—the resistance falls to 400ω or 500ω, and in this case Mr. Fish's first value would be

$$\frac{1,000}{500} = 2 \text{ amperes.}$$

To my mind, a provision which depends upon an uncertain and extremely variable physical condition, upon the nature of the contact made, and upon other considerations which it is not necessary at present to discuss, is by no means satisfactory. The matter is an important one, but as the question really deals with workshop practice, not calling for any elaborate theories, would it not be best met by taking means to ensure the invariability of R within reasonable limits? This might be done with less trouble than is now entailed by the precautions governing the safety of coalminers, and if insisted upon by those having control of electric light and power enterprises, should procure immunity from danger for those engaged in practical work. Suitable clothing, etc., should be worn, and the hands and wrists soaked in a non-conducting oil or composition, or frequently dried with a naphtha or paraffin rag. Before engaging in any possibly dangerous work the resistance of the operatives should be measured. In this way the risk would be greatly minimised. You would not venture to place a delicate instrument in circuit with an unknown E.M.F., why should you, then, venture a human life blindly? If a law were passed prohibiting the employment of workmen whose hand-to-hand resistance should at any time during working hours be less than ten times the voltage, a way would very soon be found out of the difficulty.—Yours, etc.,

QUERIST.

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SOME ELECTRIC LIGHTING CENTRAL STATIONS IN EUROPE AND THEIR LESSONS.*

BY PROF. GEORGE FORBES, F.R.SS. (L. AND E.), MEMBER.

(Concluded from page 243.)

I am not going to discuss at present the whole question of insulation, but rather to draw conclusions from the experience of the past. At the present moment vulcanised indiarubber and okonite are the substances which have the highest reputation for durability and high insulation under all conditions. These, like other cables, are sometimes covered with lead, but in their case it is only as a mechanical protection, especially during the process of laying, because the destruction of the lead would not destroy the insulation. Of late years a class of cables has been much praised, about which I wish to speak. The copper conductor, stranded or otherwise, is covered with any fibrous material, preferably jute, impregnated with bituminous oils. This covered core is enclosed in the lead pipe. In this class of cable the insulation depends upon the lead being water-tight. We all know of many places where this type of cable has done good work for a limited time, and many of us were inclined to believe that it was quite satisfactory; but I think I am right in saying that none of us know of its having worked successfully in any place for three or four years. I have said that a cable of this kind has hitherto been exclusively used in Berlin, the lead being covered with layers of tape or braid soaked in a preservative compound, and the whole armour-plated with two closed spirals of iron ribbon. I regret to have to tell you that this insulation has been a failure. It goes on well enough for about three years, then the lead gives way, the covering on the copper is permeated, and chemical or voltaic action sets up in the copper, which itself becomes disintegrated. So far as experience goes, this type of cable seems to me to be unsuitable for permanent work with the electric light. I trust that in the discussion we shall have some facts brought out. I had hoped, from what Berthoud and Borel, and also Waring, had done, that this would not be so, but the Berlin experience leads me to think otherwise; and on looking through the testimonials of makers I do not find that these cables, when placed underground, have ever worked electric light circuits beyond the three years fixed by the Berlin people as being destructive. I have been told, but I cannot believe it, that there is one company in London actually proposing to put such lead-covered cables without covering into iron pipes. Of course, everyone knows they would soon be eaten into by galvanic action.

At Berlin and elsewhere I believe there is the intention of trying some modification of the system of using bare conductors, first practically used by Mr. Crompton at South Kensington. Taking economy into account, it is probable that for low-tension circuits this is an admirable plan. It is probable that it may also be adapted to high-tension circuits by using oil insulators to support the bare conductors. When copper strip is used, it is necessary to raise the cover of the trough in order to increase the number of conductors: this is very expensive. For my own part, I would prefer a drawing-in system, if it were otherwise equally good.

No information has ever been given as to (1) the maximum or (2) the minimum insulation resistance of the conductors at Kensington Court, but perhaps this information will be given during the discussion.

At the present moment it seems to me that the only types of underground cable proved suitable for permanent work are either bare copper supported on insulators, or else vulcanised indiarubber, or perhaps okonite. Especial care must be taken to avoid an insulator which is injured by the gases which permeate the soil of a town, or which has the property, like pitch, of becoming viscous, and so letting the copper become decentralised.

Meters.

The next lesson which the experience of foreign stations in Europe and America has taught us is the importance of charging the consumers of electricity by meter, like gas. I find that at present most companies in this country are charging the larger proportion of their consumers by contract, making an annual charge for each lamp. This appears, from evidence collected everywhere, to be a fatal mistake. It is the universal experience that those stations pay best where meters are used. In many stations it is found to be the best plan to make a fixed annual charge, which may be put down as the rent of meter, and then an additional charge proportionate to the quantity of electric current supplied. This has the advantage of preventing customers putting in place a large number of lamps which during the greater portion of the year are idle, but which on festival occasions may all require current. Such idle lamps are very expensive to the suppliers, because a large reserve of machinery must be lying idle during the whole year to be ready for such occasions.

Within the last month I have described before the Society of Arts* the different meters which are valuable, without pretending to estimate their relative value. For continuous currents we have the Edison and Aron meters, for alternating currents we have the Schallenberger meter, and for both classes my own "Windmill" meter.

Converters.

The induction apparatus used with alternating currents is called a "converter," "secondary generator," or "transformer." The reduction of pressure from the primary to the secondary circuit is generally 20 to 1, but sometimes more. A large number of types have been invented. I have elsewhere described the Westinghouse converter, which I have tested and found to be very efficient, even though the largest one he is in the habit of supplying is only for 40 lights.

Only the larger size of Zipernowski converter is so efficient. Three sizes are made, varying in efficiency from 95 down to 88 per cent., though the latter is a converter suitable for 25 lamps. Many of the types which are made in England I feel sure are far from efficient. There is a general opinion that the loss in the converter is necessarily small. This is by no means the case. A great deal of care must be taken in the design to get a satisfactory result. I think there is a general idea that any of the converters now on the market in England will give an efficiency for the average number of lamps in circuit of about 90 to 95 per cent. I should be much surprised if there are more than two types in use in this country which have an efficiency for the average number of lamps over 70 per cent. Yet, so far as I am aware, no maker in this country ever tests the efficiency of the converters which he supplies. The efficiency of a converter falls when it is under-loaded. If the converter in a house is adapted for 100 lamps, and only three or four lamps are in use, then, with many converters, the current which is being used is double or treble what is required for the lamps. This defect in some converters is clearly shown in the load diagram of the Grosvenor Gallery installation, where during the hours of minimum supply the current sent out from the station is seen to be abnormally high—far above that of the load diagram of other central stations—and at the hours from 4 to 6 a.m. in October current sufficient for 4,000 lamps is indicated on the station meter. This curve shows a loss of 20 per cent. The type of converter which Westinghouse has perfected is one of low magnetic resistance. The worst ones now being made in England are of high magnetic resistance. The waste in a converter, independent of magnetic friction, varies as the square of the magnetic resistance.† The waste due to magnetic friction varies as the length of the magnetic circuit, if the induction in the iron is the same. These high magnetic resistance converters require a great deal of copper. The magnetic friction is so great that they would probably work better with an open magnetic circuit, as shown by Lord Rayleigh (*Phil. Mag.*, 1886).

Slow and High Speed Engines.

I need hardly tell you that the most startling difference I found between the best European and American practice is the question of speed of revolution of dynamos. In America, 1,000 revolutions a minute is the normal speed for an alternator of 250 h.p.; in Rome, the 600 h.p. dynamos revolve at 125 revolutions per minute; at Berlin, the 400 h.p. engines at 80 revolutions per minute. In Europe there is a tendency to condemn high speed as such, whereas high speed is more objectionable only in the type of machine where the revolving part is more massive, less perfectly balanced, less capable of standing centrifugal strains, and has a longer distance between the bearings. In every other point high speed is an advantage, especially in economy of plant. Now compare the Zipernowski and the Westinghouse dynamos, choosing of the former the one without Pacinotti teeth on the armature, as made by Elwell-Parker. These two machines are electrically identical, but in one the armature is fixed, in the other the field-magnets. The armature can, and the field-magnets cannot, be perfectly balanced. The weights are not very different. The armature is more capable of standing centrifugal strains than the coils of the field-magnets. For all these reasons, the Westinghouse may be run at high speed, and gain all the advantages of economy. Of course the necessity of introducing belting has to be considered in this case. But then turn to the Parsons alternator, which drives direct, and being the lightest, best-balanced machine, with great capacity of resisting centrifugal strains, and with the only scientific bearings in the market. Here we have a machine where all the advantages of high speed may be safely acquired and great economy introduced. People are apt to forget that slow speed means large machines with no increase of output.

Speed of Alternations.

Now I come to a very important point. What speed of alternations shall we use? In Rome they have 83 alternations, or 41 complete periods, per second. In America the Westing-

* Paper read before the Institution of Electrical Engineers, Feb. 28.

* Society of Arts *Journal*, January 25, 1889.

† See my formulæ for converters, *Journal* of the Society of Telegraph Engineers and Electricians, vol. 17, part 71, p. 153.

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house Company have 267 alternations, or 133 periods, per second. What are the advantages and disadvantages, and why have these makers adopted different plans? I will answer this in detail to the best of my ability. First, Westinghouse went to rapid alternations because he wanted his converters to be of reasonable size. Second, he wanted to economise plant by using high speeds, and it would be very difficult to have slow alternations with high speed. Third, Ganz and Co. (Zipernowski) wanted to drive their machines at slow speeds, under which circumstances they cannot easily get rapid alternations. This is how these things were arrived at. Now let us see what the results are.

1. With rapid alternations the size and cost of the converters is diminished. Most people seem to think this is a small matter. A moment's consideration shows that it is not so. It is found that in most houses the size of the converter does not exactly fit the number of lamps, so a size larger must be used. Hence, for a 7,500-light plant converters for 10,000 lights are required. The price of these, for the sizes used in houses, is (as the average of many makers) £5,000. The cost of engines and dynamos combined (Parsons) for the same would be about £6,000. You will now see that the cost of converters is as important as anything else.

Mr. Kapp has stated, I venture to think erroneously, that the size does not vary with the speed of alternations. This is opposed alike to experience and theory. Westinghouse knows this. I am informed that Mr. Ferranti knows it, and Mr. Zipernowski has told me so in a recent letter.

2. There is, however, an important gain by slowing the alternations. It is then easier to work in parallel. This is due to the fact that the machines have more time to get into step. If I considered parallel working essential to success, I should say, "Sacrifice the cost of converters, and use slow speed." Otherwise, I should say, certainly and without hesitation, "Use rapid alternations to increase the efficiency and economy."

Working in Parallel.

The experience of Rome is encouraging to anyone who thinks parallel working essential. For my part I do not. Subdivision of mains is far more practical in most cases, and enables you easily to cut out special districts if a fire or other trouble occurs. It also gets over the trouble of increased resistance in large conductors with alternating current, dwelt on by our President in his opening address. If I have more than one station in a town, and I want one to assist the other, I would do so by trunk lines between the stations, to which a dynamo can be attached at one end and feeders at the other. Of course, both stations must supply the same type of converters; hence, in such a system it would not do to use dynamos of various speeds of alternations at the different stations. I would certainly prefer parallel working as being simpler for the men at the central station, if no complications are introduced to make the machines work in parallel, and if the system were equally economical, but I do not consider it at all essential. I venture to think, however, that the plan now universally proposed for making machines work in parallel will not long be tolerated. This is to introduce into the machine a large amount of injurious self-induction, thus diminishing the plant efficiency and rendering the equalising of pressure with varying loads very difficult. I have confidence in the ingenuity of our inventors, who will soon devise a less objectionable plan.

Automatic or Hand Regulation.

The question now arises whether the regulation of potential should be accomplished by hand or automatically. In all low-pressure systems, such as Berlin, it is done by hand. A workman soon gets to know at what hours special attention must be paid to this, and on the low-tension system with shunt-wound or compound-wound machines the regulation required is slight. Where the saving in attention is not very great it is always unadvisable to trust to automatic dodges. The case of alternating-current dynamos with high self-induction is very different, for the electric pressure then varies enormously with the current. In this connection such a machine resembles a series-wound direct-current machine with high resistance. The changes are so frequent that some automatic adjustment is necessary. Ferranti, Lowrie, and others have used the sagging of a wire to effect this, and they regulate the pressure at the dynamo, not at the centres of distribution, which is wrong. The apparatus looks too delicate for an engine-room. But Ganz and Co. use a very practical type. They also regulate for the centres of distribution. I also prefer the method used by Ganz and Co. of regulating the large changes by hand, and only the small changes automatically. This is necessary, owing to the very large adjustments necessary with alternators of high self-induction.

In conclusion, I feel confident that all those who are working to maintain England's supremacy in this department of industry will agree with me that the practical details necessary for successful central station working must be thoroughly well thought out beforehand, and that much saving of time and money can be effected by gathering hints from those who have spent years of time and tens of thousands of pounds on these details.

I frankly admit that I have learnt more that is of practical value in this line from the inspection of actual work done than by reading books.

But we must remember that the low price of gas in England, the cheapness of coal, and the relative cost of labour, all introduce special factors which will partially differentiate the English practice either from that of the continent of Europe or of America.

I wish, now, that the last words of this paper may be words of thanks to the gentlemen in other countries—whether in Europe or in America—who have the control of central stations for the courtesy which they have extended to me in my endeavours to assist, to the feeble extent possible to me, in maintaining the position of this country in the progress of this new and important industry.

LONDON COUNTY COUNCIL.

At the meeting of the London County Council on Tuesday last, the General Purposes Committee reported that they had had before them the following important letter from the Board of Trade:

"Board of Trade (Railway Department),
London, March 13, 1889.

"My Lord,—I am desired by the President of the Board of Trade to inform your lordship that the question of electric lighting in the metropolis is at present receiving the serious consideration of this department. Thirteen applications for provisional orders under the provisions of the Electric Lighting Acts, 1882 and 1888, in respect of areas within the metropolis, are now before the Board.

"In dealing with these applications the Board of Trade are at once confronted with two important questions of principle—(1) What should be the extent and nature of the area to be granted? (2) Should or should not concurrent powers be granted to two or more companies within the same area?

"As regards the former, many considerations must be taken into account—*e.g.*, what is the financial position of the undertakers applying for statutory powers in any given area; how far any one company would be in a position satisfactorily to supply such an area; and in connection with this much would depend on what distance electrical energy for electric lighting purposes can be safely and conveniently furnished from a central station.

"As regards the latter question, on the one hand it appears to the Board of Trade to be highly desirable to avoid the grave inconvenience to which the public were subjected when there were competing gas companies supplying the same areas in the metropolis, and, further, in the case of electric lighting, that uncertainty exists whether mains can be satisfactorily laid in close proximity to each other. On the other hand, some of the local authorities in the metropolis appear to be desirous to encourage competition, and are anxious to avoid the creation of a monopoly or *quasi*-monopoly for electric lighting by giving any company exclusive powers for any one area.

"Before deciding on the action to be taken on the applications at present before the Board of Trade, they propose to adopt their usual procedure and to hold a local enquiry, of which full notice will be given, and at which all those interested can be heard, but they are anxious to take no definite step which may have important bearing on the future policy to be pursued with regard to electric lighting in the metropolis without communicating in the fullest manner with the County Council of London.

"In this determination they are greatly influenced by the consideration that before long the jurisdiction which the Board of Trade now exercise in regard to electric lighting matters in the metropolis may be transferred to the County Council, and they would therefore be most unwilling to take any action which might hamper that body in dealing with the question in the future.

"With this view they propose, as soon as the report of the enquiry has been received, to forward it to your lordship for the information of the County Council, and I am at the same time to express a hope that this Board may then be favoured with any observations which the County Council might wish to offer upon this large and very important question.—I have the honour to be, my lord, your lordship's obedient servant

"Henry G. Calcraft.

"The Earl of Rosebery."

The committee had also received a further letter from the Board of Trade stating that the local enquiry referred to would take place on April 3 next, at 10.30, before Major Marindin, R.E., at No. 8, Richmond-terrace, Whitehall.

It was agreed that several members of the committee should attend the enquiry.

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

THE BOARD OF TRADE.

The letter of Mr. Calcraft, from the Board of Trade, to Lord Rosebery, the chairman of the London County Council, is just at this moment of great interest. The letter is given elsewhere. It states that at the present time there are 13 applications for provisional orders for metropolitan districts under consideration at the Board of Trade. Further, before deciding upon the action to be taken on these applications, it is intended to hold a local enquiry, which enquiry is to be held on the 3rd of April next, at 10.30, before Major Marindin, R.E., at No. 8, Richmond-terrace, Whitehall. The result of this local enquiry will undoubtedly be of very great, if not of supreme, importance to the electrical industry, so far as the distribution of light and power are concerned. Mr. Calcraft's letter mentions two important questions of principle involved in the consideration of the applications: (1) What should be the extent and nature of the area to be granted? (2) Should or should not concurrent powers be granted to two or more companies within the same area?

With all due deference to the wisdom of the Board of Trade, we should say these questions do not really merit five minutes' consideration. The answer to the first cannot be foretold by any system of rules and regulations. The extent depends upon the capital of the supply company; the nature cannot be affected by any regulations of the Board of Trade. Their rules will not turn a residential into a manufacturing district, nor an area covered with artisans' dwellings into streets of theatres. But we should contend that the "extent of area" depends again upon the answer to the second question, "concurrent powers" or "non-concurrent powers." Men who contend that "concurrent powers" should be granted for the purpose of encouraging competition, are not far removed from the category of those dubbed by Carlyle as mostly inhabiting this mundane sphere of ours. If the Board of Trade, or any other authority, be desirous of seeing supply companies "cut each other's throats" at the expense of shareholders, let concurrent powers be granted. Otherwise, rigidly exclude one company from another's district. There are a hundred sensible ways of keeping down "selling prices," rather than driving merrily along the road to the Bankruptcy Court. If electric lighting is to be a success, two sets of distributing mains cannot be permitted in the same district. If such a system did not quite double the initial cost, it would nearly do so; and the cost of maintenance, and the cost of litigation, would be enormously increased. It is useless to consider electric lighting in the dilettante way half the supply companies and contractors would have it considered. If they obtain a provisional order for a district, their aim should be to light every room, be it in princely mansion or labourer's

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hut, in the district. They should not be permitted to pick or choose; but this really seems to be provided for in the Act, and so need not be discussed. The plans of the supply company should be sufficiently elastic from the very first to permit the supply of all the electric energy, both for light and power, likely to be wanted in the district, not only in the immediate present, but in the distant future. The gas companies do not lay mains of only sufficient capacity to supply two houses now built along a long road in a new district, but of sufficient capacity to supply all the houses in the road when they are built. The district allotted then to any company should be proportional to the capital of the company—that capital being sufficient to enable the whole area to be supplied. A more important question by far than either of these drafted by the Board of Trade is, whether concurrent powers should be given to different companies for the distribution of light and power. At the present moment those who favour the alternate current system of distribution cannot provide for power users, and the question whether the wants of the latter are to be supplied by another company in the same district, is important. Here, again, English notions seem to us to follow the motions of a cat dancing on hot bricks, ever changing, never resting for a moment on the same spot. The letter of Mr. Calcraft does not seem to contemplate the double distribution, and yet the one not referred to is commercially of far greater value than the one mentioned. We again say it seems a sheer waste of money to have two distributing systems, even if one be for light and the other for power, in any district. Probably the enquiry to be held will lead to the expression of various opinions upon this subject, and may elicit information not at present accessible to the public. We are convinced, however, that the questions cannot be separated. It will, perhaps, be advantageous to the industry when the powers governing the metropolitan area are handed over to the Council, for then the subject can be looked at as a whole, while now each application has to be treated separately and individually, except, of course, when several applications are for the same district.

The electrical industry should be well represented at this local enquiry, and see that the right sort of evidence is given, evidence the result of personal experience, and of a practical character, and not evidence of the "I believe" character. What is wanted is the "I know," no matter how egotistical it may seem, in contradistinction to "I have heard," "I have seen," and "I believe." The man not actually engaged in the work is always twelve months or more behind those who are always constantly putting down and arranging installations. If subsequently this enquiry has a bad influence upon the industry, there will be no one to blame but the members of the profession themselves. We trust, too, that the evidence tendered will be on a wider basis than individual welfare. The aim should be to guide the Board of Trade and the London County Council in the right direction for the true development of distribution of electrical energy. It must be recognised that whatever action is taken by the London County Council will have a very direct influence upon every other Council in the kingdom that has to consider similar questions.

USEFUL ELECTRICAL QUESTIONS FOR TROPICAL CLIMATES.

We are always glad to hear from our able and esteemed contemporary, the *Electrical Review*, but we fancy that in this instance our queries have been misunderstood. We asked these questions with a view to obtaining a record of the experiences of our readers in the tropics; whereas our contemporary, taking it for granted that the conditions are everywhere the same, has disposed of the whole matter with a few cut and dried extracts from Clark and Sabine. The questions we asked were as follows:

1. Is the coefficient of variation of resistance with temperature mathematically correct for copper coils, and more especially galvanometer-coils?
2. Is capacity variable with temperature?
3. Are high-resistance coils of platinum-silver reliable, or is it not a fact that, under certain climatic conditions, they show residual charge—that is, act to a certain extent as a secondary cell, destroying the accuracy of tests?

Now, we have not asked these questions without good and sufficient reason, and we venture to think that in the immediate future we shall be able to place a few interesting facts before our readers.

With regard to the coefficient for copper coils, 0·209 per cent. per degree F., it is all right, of course, within the limit of reasonable temperatures; but is it correct when the temperature is excessive? Take, for instance, the case of a galvanometer whose adjusted resistance is 6438 ohms at 66deg. F. The temperature at time of test is 110deg. F., a difference of 44deg., or in resistance of 592 ohms (about). When our readers get these differences, let them test their galvanometers and see if the calculated equals the observed increase. Our experience does not confirm the mathematical accuracy of the coefficient for high temperatures.

In reply to our second question, our contemporary says, "It is generally admitted that the effects of temperature on capacity are, so far as practical work goes, absolutely *nil*." It is a matter of opinion as to whether sufficient is known of condensers to enable us to thus dismiss them as among the subjects that are exhausted. Upon what does capacity depend? Upon the area of the plates, and the nature and uniformity of the dielectric. If the plates vary, and the insulation varies with temperature, capacity must vary as well—whether to any appreciable degree remains to be seen. It may not be noticeable in, say, a ten microfarad condenser, but it is noticeable in a submarine cable of, say, 280 microfarads capacity, whose shore ends are laid through warm shallows. It is only reasonable to suppose that it should be so, for the area of the copper varies with temperature, and the dielectric also varies with temperature, pressure and period of immersion. As a matter of fact, the *apparent* capacity of a submarine cable may be said to vary with the insulation; for the reason that although a higher or lower absolute resistance may not argue a capacity higher or lower than the given quantity while the cable is undergoing electrification, it has a decided influence upon the discharge readings, and therefore allows an error to creep into the test. To make this clear, we will suppose the cable to be theoretically perfect. That being so, it will retain its charge for an

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indefinite period, and a discharge taken at any time will give the true capacity value. If, however, the cable be imperfect, there will be a loss during the interregnum between charge and observation; and the longer the interval and the lower the resistance of the dielectric the greater that loss will be. It will be admitted that in the event of a broken-continuity fault we have to rely entirely upon the standard capacity of the cable. We will suppose this to be 0·350 micro per knot, and further suppose the cable to have a length of 1,000 knots, thus

A	50 knots	900 knots	50 knots	B
	Hot shallows	Deep sea.	Hot shallows	

The value 0·350 micro per unit of length is, under the most favourable conditions, obtained from a test of the total capacity (taken shortly after immersion) divided by the length in knots. The value is given, and no one troubles further about it. It is unalterable.

Some years afterwards, in the middle of a tropical summer, the cable develops a broken-continuity fault, and we proceed to localise it, heedless of the facts that (1) the insulation basis (if we may be allowed the expression) is changed with prolonged immersion in deep water; (2) the C R is different, owing to difference of temperature; and (3) the shore ends are laid in hot shallows, whereas the deep-sea portion is in cold water. Is the C R the same in the shallows as it is in the remainder of the section? Is not the insulation resistance much lower? There is not the same loss of current throughout; the cable is not homogeneous, and cannot be considered so, electrostatically or otherwise. We remember a case in point. The deep-sea section of a 950-knot cable, tested from the ship, gave very nearly the correct—that is, the standard—capacity, but the 40-knot shore end laid in shallow water presented an abnormally low insulation resistance, and tested from ship and shore 0·02 micro per knot less, which, according to the stated capacity of that particular cable, made a difference in the length of three knots—a very appreciable error, for with the end sealed and the 40-knot section perfect, the capacity test (if the standard electrostatic cap: was correct) should have given the distance to within a fathom.

As regards condensers proper, they are continually going wrong in the tropics, and very seldom test to their marked values. We will give some further particulars later on. Meantime we should like our foreign readers to favour us with their experience. We shall have something to say next week about our third question.

ON THE DESIGNING OF CONTINUOUS CURRENT DYNAMO MACHINES.*

BY PROF. JAMIESON, M.I.C.E., F.R.S.E.

The discussion on this paper took place on February 26, 1889.

Prof. Jamieson explained the leading features of his paper by referring to the wall diagrams which he had prepared of the magnetic and electrical circuits of the Kennedy and Faraday dynamos. He concluded by working out the following demonstration of how magnetic fields are measured, and of how Kapp's constants are derived. He also stated what changes had to be made in these constants to suit different degrees of magnetisation and qualities of iron.

Unit Poles.—The force, F, exerted between two poles of strengths, m and m', placed at a distance, L, centimetres from each other, is

$$F = \frac{m \times m'}{L^2} \text{ dynes.}$$

If m and m' are each unit poles, and their distance apart is 1 centimetre, then

$$F = \frac{m \times m'}{L^2} = \frac{1 \times 1}{1 \times 1} = 1 \text{ dyne of force.}$$

A dyne is unit force in the C.G.S. system, or that force which, if acting for 1 second on a mass of 1 gramme, imparts to it a velocity of 1 centimetre per second.

* Paper read before the Institution of Engineers and Shipbuilders in Scotland.

Method of Reckoning the Number of Magnetic Lines of Force in a Magnetic Field.—Suppose a unit free pole, p, situated at the centre of a non-magnetic sphere of unit radius, r (1 centimetre), and that the whole surface of this sphere is plotted out into squares of unit area (1 square centimetre). Further, suppose that free unit poles, $p_1, p_2 \ldots p_{12}$, are placed at the centres of *each* of these squares, then it follows from the previous statements that the unit pole at the centre of the sphere would exert unit force (or 1 dyne) on each of the unit poles at the surface of the sphere.

But the surface of a sphere $= 4\pi r^2$.

And since $r = 1$ centimetre or unit length, the surface of the sphere is $= 4\pi$ square centimetre; therefore there are 4π dynes of force emanating from the central unit pole, or what is usually termed 4π magnetic lines. Consequently, a magnetic line represents a force of 1 dyne.

If we have any other magnetic pole of strength, M, then the number of lines which flow from it are equal to

$$4\pi M \text{ lines.}$$

Let $M = 100$, then

$$4\pi M = 4 \times 3{\cdot}1416 \times 100 = 1{,}257 \text{ lines.}$$

Magnetic Fields Produced by Currents in Solenoids.—We will make reference here to a spiral conductor or solenoid (without any iron or other core) conveying a current which produces a magnetic field. Then the intensity or number of lines per square centimetre of its cross-section (at right angles to the direction of the lines and at the centre) is equal to

$$\mathbf{H} = \frac{4\pi n C}{l}$$

(see index to symbols below).

In another case the same solenoid is fitted with an iron core, and the same current is supposed to be sent through it. Now, however, we find that the number of magnetic lines per square centimetre of cross-section (within the bar) have increased to

$$\mathbf{B} = \mu \mathbf{H} = \mu \frac{4\pi n C}{l}.$$

1. *Method of deriving Kapp's constant* **2** *from the fundamental formula for* **H** *and* **B**:

Let **H** stand for intensity of field, or C.G.S. lines per square centimetre.

„ **B** „ magnetisation induced by **H** in the iron in C.G.S. lines per square centimetre.

„ μ „ permeability of the iron core.

„ C „ current in solenoid in C.G.S. units.

„ n „ number of turns of spirals in solenoid.

„ l „ length of solenoid in centimetres = 2·5, **L** (inches).

„ s „ cross area of iron in sq. cms. = 6·45 **S** (square inches).

$$\mu = \frac{\mathbf{B}}{\mathbf{H}} \qquad \therefore \mathbf{B} = \mu \mathbf{H}.$$

$$\text{But,} \quad \mathbf{H} = \frac{4\pi n C}{l}, \qquad \therefore \mathbf{B} = \mu \frac{4\pi n C}{l}.$$

Now, as stated before, 1 Kapp line = 6,000 C.G.S. lines.

∴ The Kapp lines induced in the core by current in solenoid equal the

$$\frac{\text{number of C.G.S. lines per sq. in.} \times \text{area of core in sq. ins.}}{6{,}000}$$

$$\mathbf{K}_L = \frac{\mathbf{B} \times \text{area in sq. inches}}{6{,}000} = \mu \frac{4\pi n C \times 6{\cdot}45}{6{,}000 \times 2{\cdot}5} \times \frac{\text{sq. inches.}}{\text{inches.}}$$

$$\text{,,} \quad = \mu \frac{4\pi\, 10\ {}^{1}A \times T_{mw} \times 6{\cdot}45\, \mathbf{S}}{6{,}000 \times 2{\cdot}5\, \mathbf{L}}$$

$$= \mu \frac{3{\cdot}19 \times \text{exciting force} \times \mathbf{S}}{6{,}000 \times \mathbf{L}}$$

But the magnetic resistance

$$\mathbf{R} = \frac{\text{exciting force}}{\text{magnetisation}} = \frac{A \times T_{mw}}{\mu \dfrac{3{\cdot}19\, A \times T_{mw} \times \mathbf{S}}{6{,}000 \times \mathbf{L}}}$$

$$\therefore \mathbf{R} = \frac{6{,}000\, \mathbf{L}}{3{\cdot}19\, \mu\, \mathbf{S}} = 1{,}860 \frac{\mathbf{L}}{\mu \mathbf{S}}.$$

Now, where $\mu = 930$ for magnet wrought iron, as found

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by experiment, or at the rate of about 14 Kapp lines per square inch,

$$\mathbf{R}_m = \frac{1{,}860\ \mathbf{L}_m}{930\ \mathbf{S}_m} = 2\frac{\mathbf{L}_m}{\mathbf{S}_m}.$$

N.B.—For other values of, μ, the constant **2** varies accordingly.

2. *Precisely in the same way the constant* **1,440** *is found for the air space.* For,

$$\mathbf{R}_{as} = \frac{6{,}000\ \mathbf{L}_{as}}{3{\cdot}19\mu\ \mathbf{S}_{as}} = 1{,}860\frac{\mathbf{L}_{as}}{\mu\ \mathbf{S}_{as}}.$$

Now, if the air space was simply filled with air alone, μ would be equal to 1, and 1,860 would be the constant; but it is to a large extent filled by the insulated copper wire of the armature-coils, and Mr. Kapp has found, from an average of a number of experiments, that this increases the permeability, μ, to 1·36.

Consequently,

$$\mathbf{R}_{as} = \frac{1{,}860\ \mathbf{L}_{as}}{1{\cdot}36\ \mathbf{S}_{as}} = 1{,}440\frac{\mathbf{L}_{as}}{\mathbf{S}_{as}}.$$

N.B.—For other values of μ, the constant **1,440** varies accordingly.

3. *Tangent Function Method for constant* **2**.

Iron molecules when unmagnetised are supposed to lie so 00

When about half saturated they are supposed to be twisted by the magnetic force through an angle, so, *00*

When completely saturated they are supposed to have been turned through 90 deg. from original position, so.. 8

Kapp consequently assumes that the molecules of dynamo iron cores have been twisted through 90 deg. when completely saturated with magnetism, or that the tangent of 90deg. (which is equal to infinity) represents the magnetic resistance in this extreme condition, and the tangent of some intermediate angle represents the magnetic resistance of the actual working magnetisation.

Let σ_m stand for the efficiency of the working magnetisation, or ratio of working magnetisation to complete magnetisation.

Then if 18 Kapp lines per square inch be the working magnetisation of best wrought iron, and 26 Kapp lines per square inch be complete saturation of the iron, whilst the initial magnetic resistance = 1,

Then

$$\sigma_m = \frac{\mathbf{K}\text{ lines per sq. in. working magnetisation}}{\mathbf{K}\text{ lines per sq. in. complete magnetisation}}$$

$$= \frac{18}{26} = 69\%\text{ saturation.}$$

∴ The magnetic resistance $\mathbf{R}_m$

$$= \frac{\text{initial magnetic res} \times \tan \frac{\pi}{2}\sigma_m}{\frac{\pi}{2}\sigma_m}.$$

$$\mathbf{R}_m = \frac{1 \times \tan\ 90^\circ \left|\frac{18}{26}\right.}{\frac{3{\cdot}1416}{2} \times \frac{18}{26}} = \frac{\tan 62^\circ}{1{\cdot}049} = \frac{2{\cdot}13}{1{\cdot}049} = \mathbf{2}\ \text{(nearly)}.$$

From the foregoing it will be observed that Kapp's constants only hold good for particular permeabilities of the different parts of the magnetic circuit. Nevertheless, the formula is an extremely convenient one, and, as has been proved by the examples given, it may be trusted as far as it goes. To those who prefer to refer to tables of magnetic permeabilities, and to work with centimetres, grammes, and seconds, the following formulæ may be used, as more scientifically accurate and elastic in its application.*

The Ampere-Turns on Magnet-Coils.—

$$A \times T_{mw} = \mathbf{M}_a \frac{\left\{ \lambda \frac{\mathbf{L}_m}{\mathbf{S}_m \cdot \mu_m} + 2\frac{\mathbf{L}_{as}}{\mathbf{S}_{as}\ \mu_{as}} + \frac{\mathbf{L}_a}{\mathbf{S}_a \cdot \mu_a}\right.}{4\pi 10^{-1}}.$$

Where $\mathbf{M}_a$ stands for magnetisation of armature in C.G.S. lines.

λ „ the leakage coefficient mentioned before, or $\lambda\ \mathbf{M}_a$ = the magnetisation of the field-magnets—*i.e.*, $\mathbf{M}_a$ is less than the total magnetisation by, say, 20 per cent.

$\mu_m\ \mu_{as}\ \mu_a$ „ the permeabilities of field-magnet iron, air space, and armature core, to be obtained from tests of these or from tables.

$\mathbf{L}_m\ \mathbf{L}_{as}\ \mathbf{L}_a$ „ the same as before, but in centimetres.

$\mathbf{S}_m\ \mathbf{S}_{as}\ \mathbf{S}_a$ „ the same as before, but in square centimetres.

The object of the paper has, however, been to present the calculations and examples in as simple a form as possible, so that they might be understood and applied by any engineer or draughtsman not accustomed to the centimetre-gramme-second system of units.

Sir William Thomson said he felt a great interest in Prof. Jamieson's paper and the statement he had just made to them. The making of dynamos was no longer a thing of the rule of thumb, but everything connected with them was designed beforehand, and a careful carrying out of design ensured well-founded confidence as to what the result would be where it was estimated. That was the fundamental quality of engineering science—to be sure that if proper workmanship were given, the result would be as designed and anticipated. The formulæ put on the board, which were first given practically by Mr. Kapp about three years ago, were of great value in showing dynamo-makers how to do their work. The practical, definite mode of estimating the proper amount of material, and the quality of the same, to be used in the construction of dynamos was of great importance. There were difficulties connected with the quality of the iron which limited the definiteness which could be applied in every case to calculating the result; and here came in the scope for practical experience. He would like to hear what Mr. Jamieson had to say as to the different qualities of cast and malleable iron, and as to the importance of seeking for the very best qualities of iron in respect to magnetic permeability. In most cases of engineering there was a way of getting over defects in the quality of material, and that was by putting in more of it. That method was often eminently unsuccessful. No amount of bad material would compensate for the use of the best material in a great majority of engineering and architectural performances. But there were parts of the dynamo in which a very legitimate compromise between good material in a small quantity and bad material in a larger quantity could be carried out advantageously. One such part was the copper wire in the armature of the dynamo. If they put in a bad quality of copper there they must put in a greater quantity of it; they must increase the air space in which the copper revolved, and they would, therefore, lose enormously in the dynamo efficiency on that account. He need not enlarge upon that point, but everyone knew that in each part of the dynamo the very best quality of conducting material should be used. But now the question of the qualities of iron came in; and he would like to hear Mr. Jamieson upon that point. Suppose they had a field-magnet core of malleable iron, with pole-pieces attached to that core in the usual way, it would be much more readily made of cast iron than of malleable iron. Not only was cast iron cheaper for the same weight of metal, but it was more easily brought into the required shape, for a forging of that shape was much more expensive to produce. Besides the cost of the material the expense of putting it into that form must be considered. By putting in a larger quantity of lower-priced material in the shape of a casting than of better class iron the same purpose was fulfilled. It must be remembered, however, that there were dynamos and dynamos, electric motors and electric motors, and dynamos to be placed in ships and on land, where a difference in weight of two or three hundredweight did not become an important question. On the other hand, dynamos which were to be carried on wheels for electric locomotives, or to be put into certain classes of ships, the question of weight of material came in. He did not say that for a transatlantic liner dynamo a hundredweight or two was of much importance, but where it was to be on a locomotive it was. In speaking of this very simple dynamo made by Rankin Kennedy, he might say that he had had a very favourable experience of it. He was charmed with its simplicity. He had the use of one for some time for a temporary purpose, and liked it so well that he asked Mr. Kennedy to supply him with one, which was now working at the University laboratory exceedingly well. He had not gone into its results particularly to see the amount of work it did, but Prof. Thomas Gray, of the Royal Polytechnic, Indiana, a few months ago made an investigation with the Rankin Kennedy dynamo of the leakage of the lines of force, which they were accus-

* See section on Dynamos, by Prof. S. P. Thompson, D.Sc., in the sixth edition of Munro and Jamieson's pocket-book of "Electrical Rules and Tables," in the press.

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tomed to call it now. He might diverge here for a moment to call attention to the wonderful perception of Faraday long before the time of dynamos. Long before the time that scientific men knew anything about the distribution of scientific forces, Faraday put it so clear that professors and students, and, a little later, almost every workman, spoke in the language of Faraday of the loss due to leakage of the magnetic lines of force, and in the language of Oily (who figured half a century ago) of the flow or flux of these magnetic lines. Now, Mr. Gray had made an estimate of the leakage of magnetic forces by calculating the total number of lines of force which passed through the effective air space in the Kennedy dynamo in the place where it was effective as compared with the whole number of lines of force calculated by the formula put before the meeting by Mr. Jamieson. He (Mr. Gray) found something like 16 per cent. of leakage, but it was impossible for him (Sir William) to guarantee that figure as absolutely accurate, because Mr. Gray had left Glasgow before they could check it together. This showed that 84 per cent. of the total magnetic force generated was effective; but he trusted that others would pursue the investigation more fully. This matter was obviously of great importance with reference to its relation to the economy of the field-magnets. They would understand that some of the lines of force went this way and others that way [illustrating on the blackboard], and if a pocket compass was held in the neighbourhood it would be found by its action that a very strong force existed at some distance from the dynamo. The simplicity of the Rankin Kennedy dynamo was very marked, more particularly when contrasted with the Gramme dynamo, which was of an essentially vicious character, although of a more symmetrical and evenly-balanced form than the other. Some of the more scientific dynamo-makers preferred the Gramme despite its more elaborate construction, considering it had certain advantages which more than compensated that defect. For instance, Messrs. Mather and Platt, the well-known makers of the Manchester dynamo, instead of a single magnet, placed two parallel to each other. That was essentially a vicious arrangement. He did not say that the Manchester machine was not a really good one; but all he wanted to convey was, that this was a vicious arrangement. The total number of lines to be obtained was not increased by using two magnets. If they imagined those two cores of iron put together, and the same quantity of iron put together, the total number of lines of force would be the same as with the two magnets. Now, they compromised matters by putting the two magnets in the way described in order to obtain a symmetrical machine. He did not want to give an opinion as to the amount of the loss of magnetic lines in that machine, which, he believed, had been stated at one-half. The single-bobbin horseshoe dynamo had undoubtedly not the symmetry of the Manchester dynamo, but that quality might seem a doubtful advantage if weighed against the loss of efficiency amounting to, say, one-half of the lines of force, as it must be remembered how small a part of the whole power of the dynamo was devoted to generating these magnetic lines. But here again he had no doubt Prof. Jamieson could set them right by putting the principles involved before them. From a mechanical point of view the support given to the revolving armature in the Gramme machine was very manifest. On the other hand, the great simplicity of the Kennedy form, of which Mr. Jamieson had spoken in terms certainly not too strong, was a valuable characteristic feature, and that form resulted from applying the bearings in a very convenient way. He then referred to several other well-known forms of dynamos, and said that, in his opinion, the best form theoretically for a field-magnet was a semi-circle, but at the same time he pointed out that there would be difficulties experienced in winding on the wire on such a form of field-magnets. It had the advantage over the Kennedy dynamo by giving less leakage, and diminished the length where the magnetism had to be conducted by iron. In the Kennedy dynamo the magnetism had to be conducted through that [pointing to the diagram on the board] with a mass of iron over the magnet giving a comparatively less effective space, but the laying on of the wire was easy. A round, straight core could be easily made, round which the wire could be coiled as easily, and this being so, the ease of making and the smallness of the cost were great recommendations; besides this, cast iron could be used with advantage provided it were in sufficient mass for the lines of force which had to pass through it.

Mr. M'Whirter said, in reply to the invitation of the Chairman, that he did not know he could add anything of importance to the paper which had been so ably touched upon by Sir William Thomson, and, following such authorities as Sir William and the author of the paper, they must all be very careful in expressing any opinion. Sir William Thomson had spoken of the magnetic leakage, or, in other words, the number of lines of force which passed through the armature compared with the number passing through the yoke of field-magnets. Only the other day he (Mr. M'Whirter) had occasion to test a dynamo having field-magnets of the Kapp type—namely, the Edison form inverted. The armature was of the drum type, with Pacinotti core and Siemens winding. The field-magnet cores were of Swedish iron, the yoke and pole-pieces were of cast iron (cold blast and specially soft), the armature core was of Swedish iron discs, slotted for the winding, and carefully insulated to prevent Foucault currents. The leakage was measured with magnetic densities of from 0·55 to 17 Kapp lines per square inch in magnet cores, and throughout this range the leakage increased from 9·5 per cent. to 20 per cent. of the whole lines passing through the magnet yoke. In this dynamo the angle covered by each pole-piece was nearly 150deg., and the leakage at both poles was only about ·4 per cent. at the highest magnetisation obtained during the experiments—namely, about 17 Kapp lines per square inch in magnet cores. Mr. Kapp, in his paper read before the Society of Telegraph Engineers, November, 1886, gave as the saturation density for hammered scrap 18 lines per square inch, but seeing that in this experiment they easily got 17 lines, it was evident that Kapp's value was much too low, or our iron must have been very much better than Kapp's experimental dynamos. As showing the importance of dynamo designing, his firm, in 1884, had occasion to supply two dynamos for ship-lighting running 800 revolutions per minute. He found that these dynamos worked well, the output being, however, only 4,000 watts. Certain alterations suggested themselves to him while testing these dynamos, all in the way of reducing the magnetic resistance. The iron in the magnets was kept of the same section, but the yokes were much increased, and the joints were also much improved. The amount of iron in the armature was also increased by 50 per cent., and the result was, that now at the same speed this dynamo gave 12,000 watts. Some makers of dynamos went in for a very high magnetic density in the armature core. For example, the Kennedy dynamo mentioned in the paper had 21 Kapp lines per square inch of core, but this very high density, he thought, was obtained at too high a price. His own firm were satisfied with 17 to 18 lines per square inch of armature core. From such dynamos they got excellent work, and this density was easily obtained without excessively large magnets. Sir William Thomson had just said that no doubt the future dynamo must be simple in design, and such as could be produced at a reasonable price. His (Mr. M'Whirter's) firm had for some time got all the iron for magnets direct from Sweden; but except for special purposes, when weight was of great moment, they had decided to use in future only cast iron. He might mention that his firm had just made a much simpler dynamo even than the design called "Kennedy's," and in this cast iron was exclusively used for the magnets. The dynamo was made in two castings, including the base for tension frame. With cast iron of the quality he referred to, the permeability was so near that of wrought iron that very little difference in the magnet cores were necessary, and as this cast iron was cheap there was no difficulty in slightly increasing the diameter to make up for its lower permeability. The result of tests showed that without any sacrifice in the efficiency of the dynamo it would certainly be very much reduced in price. It was cold-blast cast iron of good quality that they used.

Mr. J. D. F. Andrews said that Mr. Kapp introduced various constants for the magnetic resistance of the air spaces with different irons, and thought it wrong to suppose the resistance of the air space was anything but constant, independently of the quality of the iron, and that consequently that constant should be varied which refers to the different qualities of iron. He also suggested the use of ampere feet per square inch of cross-section instead of ampere turns, as being much easier for the calculation prior to constructing the machine. With regard to the relative dimensions of the field-magnet iron and that of the armature, this had been determined prior to the invention of Mr. Kapp's interesting formulæ. It had been found that increasing the size of the field-magnets the sparking at the commutator was reduced until a certain relative size between the two was reached. The reason for this reduction in the sparking had never been satisfactorily explained, and he thought a correct explanation was that the magnetism produced in the armature core by the electric currents, generated in its coils, was more powerful than that in the field magnets at the point of collection, and being of the same polarity, it reduced the strength of the corresponding point in the field-magnet or tended even to reverse the polarity; consequently, the point of collection of the currents was shifted round a few degrees in the direction of rotation to a more powerful point of the field-magnets. If, however, the field-magnets were weak throughout, the point of collection would be always in advance of the brushes, because so soon as the brushes were brought up to that point, the armature current, and consequently magnetism, would increase, and reduce the power of the field-magnets that were generating it.

Mr. R. D. Smillie said that he had lately made some investigations on an old Gramme machine by Messrs. Emerson and Murgatroyd, of Stockport—a firm, he believed, now extinct—which showed the necessity of having reliable constructive data. Prof. Jamieson had drawn attention to the throttling effect due to defective design in the magnetic circuit of the small motor exhibited by him to the members. The Gramme machine referred to showed this in a remarkable degree, the magnetic permeability of the yokes relative to the cores of the

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field coils, which were of malleable iron, being only 37 per cent. The amount of iron in the armature core relative to the field cores was much too small, and, considering the intensity of the magnetic field, was far above economical saturation; while the length of the wire on the armature was excessive. The pole-pieces were also badly proportioned, considering the small amount of iron in the armature, as they enveloped 84 per cent. of its circumference, and caused a considerable loss in the magnetic field by short-circuiting in air. This was amply proved by cutting away the horns of the pole-pieces, reducing the enveloped area of the armature to 74 per cent., which had the effect, as was to be expected, of reducing the speed of the machines for the same output, 20 per cent., and also the sparking at the brushes. By clamping soft-iron plates to the yokes of the machine of sufficient sectional area to render them equal to the area of the field cores, and making a new armature, which was now in process of construction, he expected to increase the output of the machine 2·5 times, at its normal speed and with a fair figure of economy.

Mr. A. Tanakadate, being called upon by the Chairman, asked whether there was any physical basis for the assumption of magnetic resistance as constant in the Kapp's formula. He also pointed out that the theory of molecular rotation (which was first given by Weber) failed to agree with the experimental results even after the theory was modified by introducing inter-molecular friction; and stated his strong doubt of the theory by alluding to the recent results in the magnetism of nickel by Mr. Nagaoka.

Prof. Jamieson, in replying to the discussion, said: That at the late hour, and considering the large amount of their time and patience taken up prior to the discussion in explaining and amplifying his paper, it would be out of place to say much more at present. They were all much indebted to Sir William Thomson for pointing out so clearly the leading principles which should control the designing of dynamos. He believed that the remarks made by Mr. M'Whirter, together with the magnetisation curves which he had shown (and which would no doubt be published in the *Proceedings* of the institute) answered Sir William Thomson's request for further information as to the different suitablities of wrought and cast-iron for dynamo construction. Of course, no one would now think of using cast-iron for the armature cores, since the core must be laminated as much as possible, and since it was desirable to obtain a higher degree of magnetisation than could be economically attained by the employment of cast iron. Further, since the weight of the armature and the length of its conductor should be as small as possible (consistent with other conditions), the core should be composed of iron of the highest permeability. In the field-magnets, however, cast iron of comparatively high permeability might now be obtained and employed with marked advantage when lightness is not so much an object as cheapness, and where the sacrifice of a small percentage of electrical efficiency is of less importance than handiness in form, fewness of parts and joints, and general getattableness. Mr. M'Whirter referred to Mr. Kapp's paper in regard to the saturation density of hammered scrap iron. Mr. Kapp, however, qualified his statement by saying that "these figures are not to be taken as generally applicable, but simply as *averages* of the usual qualities of iron now obtainable." He would ask Mr. M'Whirter to give him an opportunity of thoroughly testing his new form of dynamo with magnets, core, and pole-pieces made entirely of cast iron; and, with his permission, he should place the results before the Institution. It was only by careful experiment and trial with different qualities of iron worked at different degrees of magnetisation that they could now hope to make any substantial improvements in or reductions of the cost of dynamos, for the machine was already so very perfect. Mr. Andrews was no doubt correct that practice first gave the stimulus to theory, for the precise relations between the magnetisation of the field-magnet and armature cores, and the exciting force was independently worked out by Dr. Hopkinson and Mr. Kapp, in conjunction with their own practical experiments and the results of dynamo makers. Their formulæ and tests, as well as the discussions upon their papers, had been the means of clearing away the "fog" which previously existed. He hoped that Mr. Smillie would give them the complete data of his experiments when he had reconstructed the old Gramme machine. In answer to Mr. Tanakadate, Kapp's constants were for a particular assumed permeability, and consequently, as mentioned prior to the discussion, they must be varied for different degrees of magnetisation and quality of iron employed. He (Mr. Tanakadate) might be perfectly correct in doubting the assumed theory of molecular rotation, but the idea greatly assisted the imagination in conceiving the observed effects.

The Chairman (Mr. Dyer) said they were highly indebted to Prof. Jamieson for his paper on this important subject, and for the practical manner in which he had embodied the results of mathematical and experimental investigations bearing upon it. Some of these investigations might at first sight seem to be of an abstract nature and to have little relation to practice, but it was found that their results were of the highest importance in the design and manufacture of dynamos. He was glad to learn from Mr. Jamieson that the designs of dynamos could be so exactly worked out now that the whole of their proportions and sizes "can be calculated and drawn down with such accuracy that, when constructed, they will fulfil the stipulated conditions to within 2 or 3 per cent., with a minimum of experiment and alteration in the workshop." Everyone would admit that that showed a high state of advancement. It was satisfactory that electrical engineers had got rid of the term "nominal horse-power," as he had recently been trying to induce mechanical engineers to do the same thing. With the conditions under which the former worked it was a comparatively easy matter to do this, and to have recourse instead to the more accurate system of brake-power. At this late hour he did not think it necessary for him to continue the discussion, more especially after the interesting discussion they had had, but he would like to remark that the paper before them was of such a kind as he would like to see often introduced to their proceedings. It manifested to a great degree the intimate relation which subsisted between science and practice, and it was altogether of such a nature that mechanical engineers would welcome such papers as often as Mr. Jamieson thought proper to prepare and read them. He was of opinion that every session they should have a similar good field night for electrical engineering as the one they now had had. He had only further to ask them to award Prof. Jamieson a hearty vote of thanks for his interesting and useful paper.

ARC LAMPS AND THEIR MECHANISM.*

BY PROF. SILVANUS P. THOMPSON, D.SC., M.I.E.E.

(*Continued from page 240*).

In the Thomson-Houston lamps, so widely used in the United States, a peculiar clutch is employed, consisting of a pair of levers jointed together, one of them being perforated with an eyelet through which the carbon rod passes. The mechanism of this lamp, shown in Fig. 14, consists of a see-saw lever, L L, pivoted at O, and provided with a long tail, T, the motion of which is moderated by an air dash-pot. Below is an electromagnet, M, in the main circuit, and above is a second, S, which is connected as a shunt. The pole-pieces of both are of conoidal shape, protruding through apertures in the armatures, *a a*, and *b b*, to give longer range of pull. The lower and upper arms of the clutch, marked R and K, close together when the tail, T, rises, gripping the carbon rod, C, and raising it. From this diagram, which also shows the electric connections, it appears that the current entering the lamp through an insulated terminal at + P, flows first round M, and then goes to the frame of the lamp. Thence it divides, the main current finding its way to the upper carbon-holder, and so through the arc to the lower carbon, whence it returns (by a route not shown) to the insulated negative terminal, —P. A smaller portion of the current flows up round the shunt electromagnet to —P. The arc is struck by the preponderating main-circuit current in M attracting the lever end of the see-saw lever, and raising the clutch. The feeding is accomplished by the preponderating pull of the shunt magnet as the arc increases in length. The resistance wire across from + P to C constitutes a cut-out circuit, which is brought into operation by the augmented current in S on any failure of the main current. The small coil connected across from + P to the lamp frame is a mere adjustment to regulate once for all the power of the series-coil, *m*, relatively to that of the shunt-coil, S.

It will be noted that in the operation of all these clutch actions there are really four periods. In striking the arc there is a first stage of affairs, where the clutch rises sufficiently to grip the carbon rod, immediately followed by second stage, during which it rises still further, and lifts the carbon rod, so striking the arc. During the third stage or period the clutch still retains its grip, but as the arc burns away the clutch is gradually lowered. This is due, in constant potential lamps, to the weakening of the main current; in constant current lamps, to the increasing opposing action of the shunt. The fourth stage is reached when the arc has burned away so far that the clutch has been lowered to the point where it begins to relax its grip, and now feeding commences, the rod slipping a little, but the clutch simultaneously rises a little, and grips again, again to descend. In a well-adjusted clutch lamp the clutch is indeed incessantly rising and falling through minute distances about the critical position. A bad clutch, or one that is deranged by dirt, will overfeed, and then rise too far, feeding spasmodically. Theoretically, all these clutches possess the retractile property so useful in keeping a steady arc when the carbons are of indifferent quality. But it is obvious that their perfection of action is impaired by dirt, dust, and inequalities in the surface of the carbon rod due to wear and tear. Clutches of the class termed "forward feeding" belong to a different category, as they have, for the most part, no retractile power. In Newton's form (1623^{83}) a piece of steel curry-comb, bent so as to form a sort of lobster-trap, encircles the carbon rod, and forces it gradually forward when mechanical vibrations are imparted to it by a lever, working with a vibration on the plan of the well-known electric bell vibrator, from the armature of a shunt-magnet. The latest variety of this species of forward feed is that of Holmes (769^{86}) shown in Fig. 15. Here, a shunt electromagnet, S, attracts an armature, *a*; the latter being mounted upon a vertical lever. The carbon rod, CC_1, is gripped between two blocks which are pressed against its sides by two curved springs, s_1 and s_2. The armature lever is attached to s_1, and is connected across by a small rod, *p*, to the

* Paper read before the Society of Arts, March 6th.

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spring s_2. When the armature, *a*, is alternately vibrated backward and forward by the magnet, the gripping blocks propel the carbon downwards. The make-and-break device which turns the current off and on in the magnet-coils, is not shown in the cut. It consists of an ingenious modification of Holmes' snap-switch.

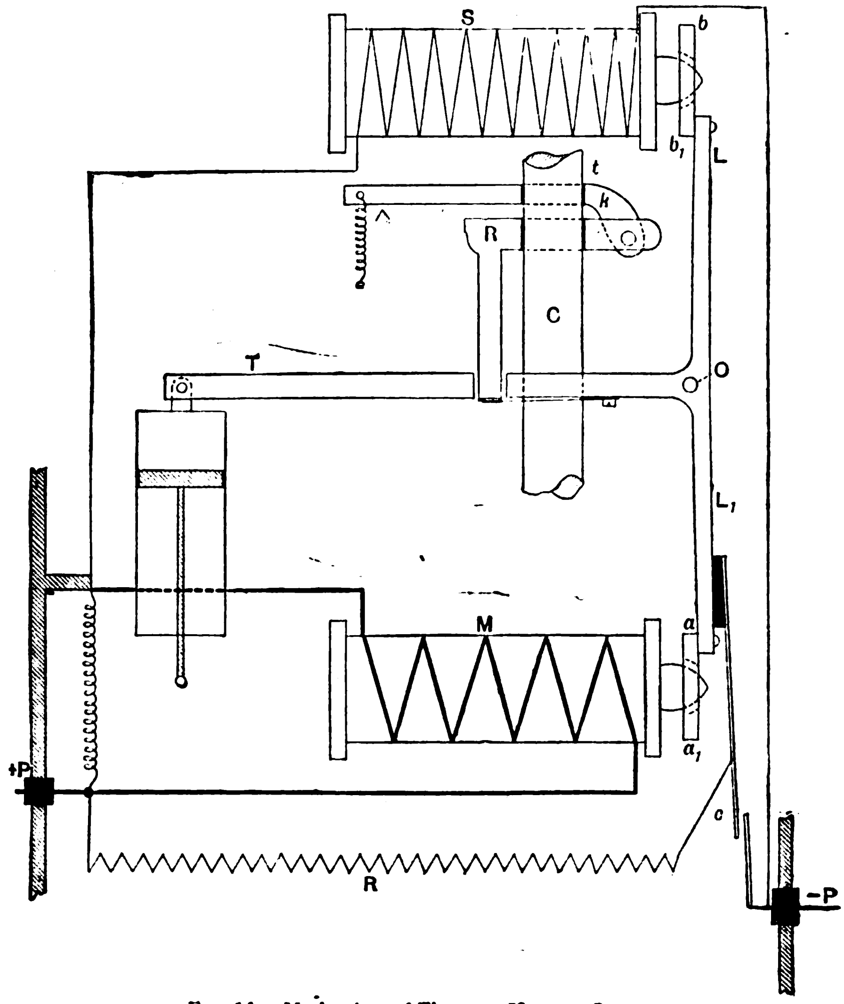

Fig. 14.—Mechanism of Thomson-Houston Lamp.

Passing to the *clutch-wheel* or *brake-wheel* type of lamps, we may remark that although so far back as 1861 Gramme attempted to construct on this plan a lamp (the existence of which was only published to the world in 1888 by M. Fontaine), this species of mechanism appears to be essentially British. The device of applying a clutch to a wheel in order to feed that wheel forward by degrees, the reciprocating motion of the clutch-lever being converted into a motion of rotation of the wheel, is already familiar to engineers in the so-called "silent-feed" movements used in spinning and weaving machinery. A clutch applied to the periphery of a wheel first grips the wheel, then turns it a little. In weaving machinery the "feed" acts in the direction in which the clutch propels the wheel, but in its application to the arc lamp the action is reversed, for the weight of the carbon rod propels the wheel in a direction opposed to the grip of the clutch, and the feeding takes place at those instants when the clutch releases its grip. The matter is best studied by reference to actual cases. Fig. 16 depicts the clutch-wheel of Common and Joel. The descending rack, R, drives the wheel, D, by means of the pivot, P. Pivoted loosely around the same arbor is a heavy lever, which is prevented by a stop,

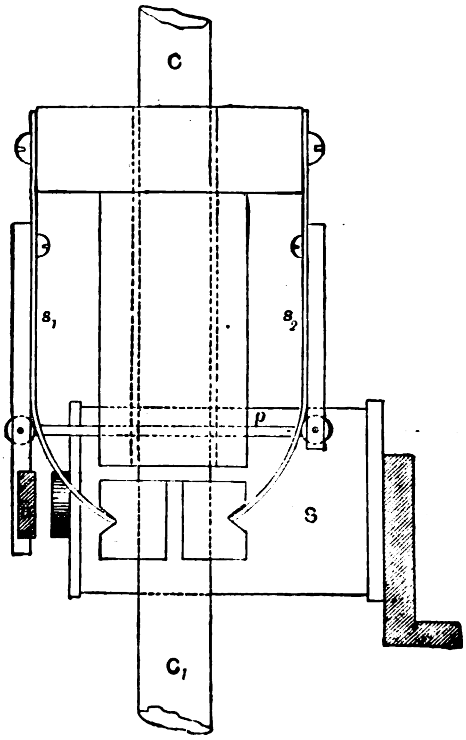

Fig. 15.—Holmes' Feed.

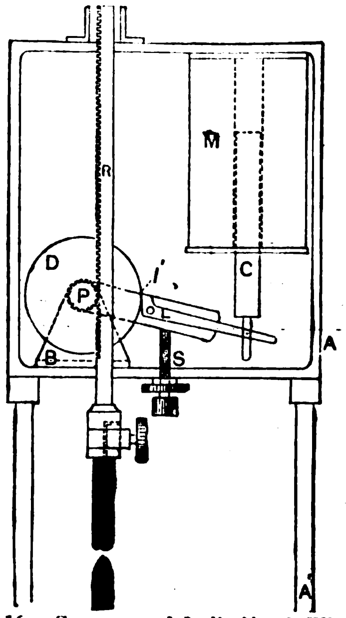

Fig. 16.—Common and Joel's Clutch-Wheel.

S, from descending too far. Pivoted to this lever at L is a second lever, with an enlarged end to grip against the surface of the wheel. The tail of this nipping lever is attached by a pin to the iron core of a solenoid, M. (The latter is wound with a main-circuit coil only if

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wanted for use in parallel, or with a main coil and an opposing shunt-coil if for use in series.) When the current in the solenoid draws up the core, the nipping lever first turns around L and grips the wheel; any further rise of the core will cause the two levers and the wheel to

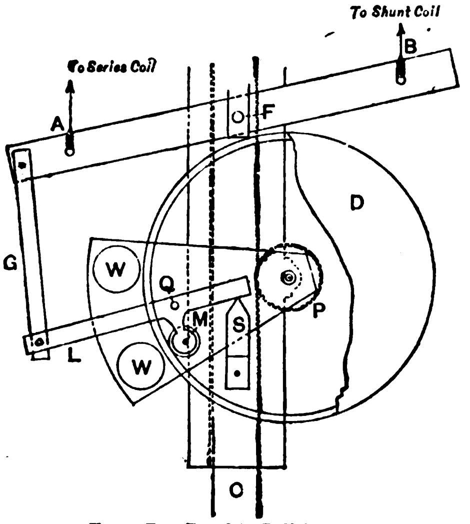

Fig. 17.—Brockie-Pell Lamp.

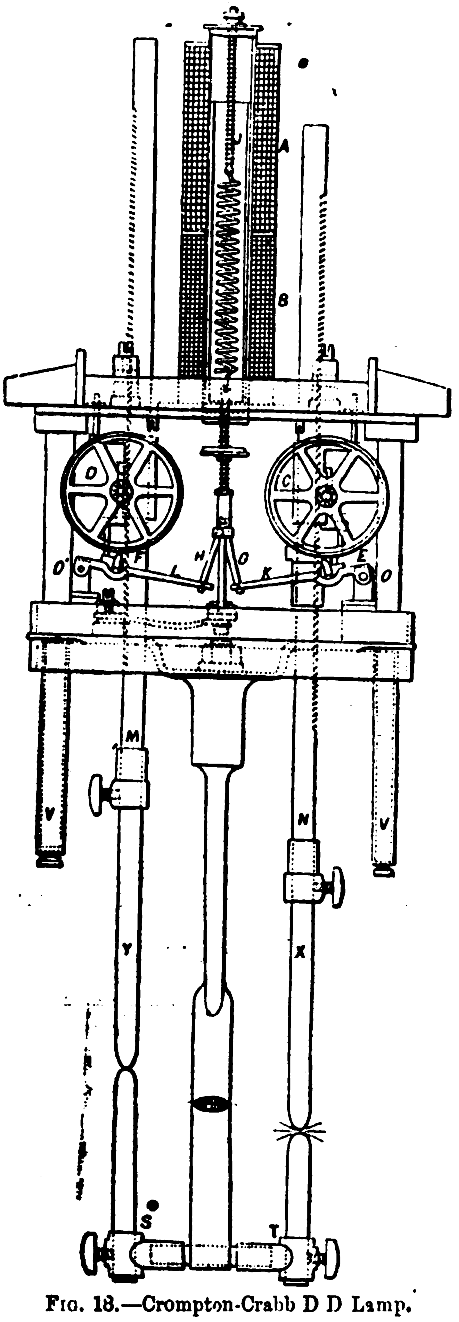

Fig. 18.—Crompton-Crabb D D Lamp.

urn bodily together round the arbor, and this second action causes the arc to be struck. Then begins the third period of action, during which the levers slowly descend until the weight-lever touches S. Then the fourth period begins; any further descent of the core causing the nipping lever to release its grip, and allowing feeding to take place, followed by a slight rise in the core and renewal of grip.

A form of clutch-wheel lamp which has become deservedly popular of late is that known as the Brockie-Pell (4419^{88} and 12681^{88}). The see-saw belonging to this lamp was shown in Fig. 6, of modes of focussing (Fig. 24). The descending carbon-rod drives a wheel having a strong projecting rim, at the inner surface of which a brake is applied. This consists of a small leather pad, *m*, fastened to a short arm which projects downwards from the nipping lever, L, pivoted at Q to a sector-shaped lever behind, which carries two weights, W W, to increase its downward bearing power. This weight-lever is loosely pivoted on the arbor, P, and turns solidly with the wheel when the brake is applied. There is a stop, S, to limit the descent, but it is in this case applied to the tail of the nipping lever. A connecting link, E, joins the nipping lever, L, to the see-saw. The internal position of the brake appears to have two advantages—namely, longer leverage around the fixed pin, making the feed more sensitive, and greater pro-

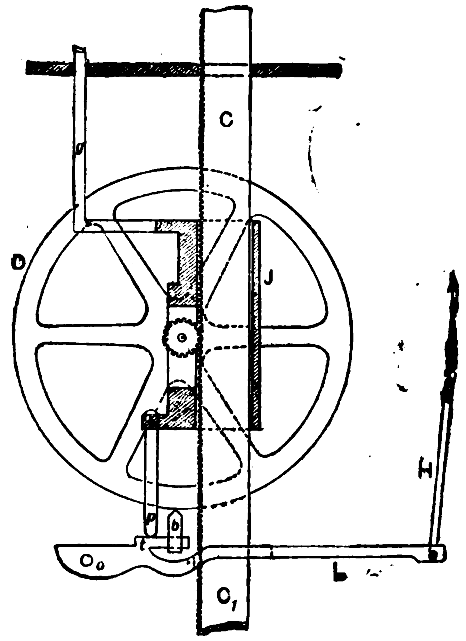

Fig. 19.—Brake-Wheel of Crompton-Cramp Lamp.

tection from dust and dirt. One peculiarity of the Brockie-Pell lamp is seen by reference to Fig. 6—namely, the device by which the core, B, of the shunt-coil is allowed a certain travel upwards before it pulls at the see-saw lever, its thinner part passing freely through a swivelled washer, *w*, on the see-saw. But the washer is of iron, and the core has an enlarged head, *h*. These adhere by magnetic attraction when the shunt-coil comes into operation.

Another very successful form of lamp is the Crompton-Crabb "double differential" (2539^{88}), shown as a whole in Fig. 18, and in detail in Fig. 19. In the lamp shown in Fig. 18 there are two carbon-rods, M and N, of which N comes first into operation, afterwards changing over. On each carbon-rod is cut a rack which drives a brake-wheel, or, rather, a pair of brake-wheels, one behind the other on the

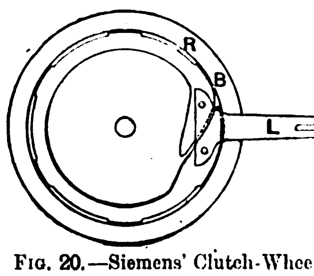

Fig. 20.—Siemens' Clutch-Wheel.

same pinion. The arbor bearing is not, as in the two preceding lamps, fixed in the frame of the lamp, but passes through a short sleeve or jockey, which, when the wheel is free to turn, can slide up or down on the carbon-rod, but is prevented from turning sideways by a guide pin, *g*, above. Below the brake-wheels stands a lever, L, pivoted at *o*, and attached by a link, H, to the core of the solenoid overhead. This lever carries a small table, *t*, and a brake-piece, *b*, faced with phosphor-bronze. When the lamp is out of action, the free end of the lever is down, and the weight of the wheels and the carbon-holder bears down upon the table, *t*, through a pin, *p*, which projects down from the jockey-sleeve. In this position the wheels do not touch the brake-piece, *b*, and are free. When the current is turned on, the main coil of the solenoid attracts its core, first drawing up the lever, which, turning on its pivot as it rises, brings the brake-piece against the rim of the brake-wheels and clamps it. Secondly, the wheels being thus prevented from turning, any further rise of the lever lifts the brake-wheel, jockey, and carbon-holder bodily (the weight of them all resting on the brake-piece), thus striking the arc. Thirdly, as the arc burns away, the lever again descends, until, fourthly, when the tail-piece rests on the table and takes the weight off the brake, the feeding begins. There are many other points of interest about this lamp which cannot here be discussed.

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Other forms of brake-wheel have been used with success, notably an elastic band-brake, resembling Appold's well-known device, applied outside a smooth wheel, in Statter's lamp (2985^{86}).

The most recent form of clutch-wheel is that devised by Alexander Siemens, 6987^{87}, illustrated in Fig. 20, The lamp to which this device is applied is a holophote lamp for search-lights, with a screw-feed, the screw being turned by this clutch-wheel. It is about one inch in external diameter, and has a projecting rim, R, within which lies an internal metal ring, B, slightly sprung outwards, and cut obliquely, somewhat in the manner of the elastic metal packing-rings used in engine pistons. The two ends of this internal split ring are joined, by two pins, to a small lever, L, which projects outwards. When a reciprocating motion, of either large or small range, is imparted to the forked end of this lever, this internal clutch alternately bites against the rim and pushes it forward, and then releases its grip and draws back. This device constitutes a true positive feed.

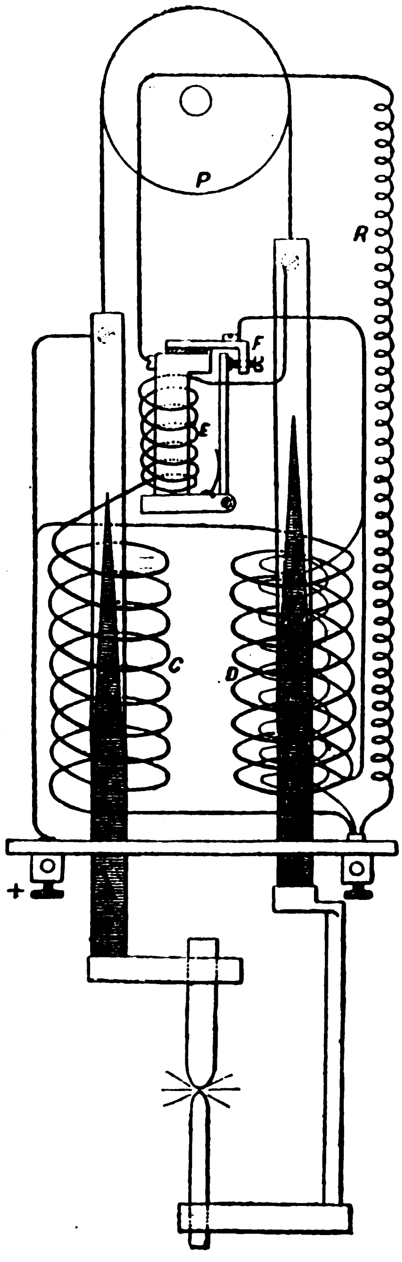

FIG. 21.—Pilsen Lamp.

The same device reappears in a recent lamp by Fein (1888), which has a main circuit-magnet striking the arc by drawing down the lower carbon, and a shunt-magnet for feeding, which vibrates an armature by make-and-break arrangement. The upper carbon-holder is smooth, of rectangular section, with a smooth feeding-roller firmly pressed by a spring against it. This feeding-roller is attached to a clutch-wheel like Fig. 20. The lamp will work even upside down. Unlike the clutch-wheel devices previously described, Fein's feed is non-retractile. The latest patterns of clutch-wheel feeds are those of Mackie (7184^{87}) and Mathis (10740^{87}). The advantages of the clutch-wheel mechanisms over the clutches that act directly on the rods, may be summed up by the remark that they render the operation of the lamp independent of dust and dirt.

Of lamps with *screw-feed* motions the most recent are the projector lamp of Siemens (6987^{87}) mentioned above, and a motor lamp by Maquaire, which is now being used at the Kensington Court lighting station. In the latter an ingenious and simple method of reversing the motion of the motor armature is adopted, so that both striking and feeding are accomplished by the same screw.

The class of lamps in which cord and pulley mechanism is employed in conjunction with a long range open solenoid, goes back to the early examples of Archeran and Jaspar. In the more complex Pilsen lamp (Krizik and Piette, 1397^{80}) two solenoids are used, each with its own coned core, the plungers being connected by cord and pulley, and each bearing one carbon pencil. The arrangement of the circuits of the recent form of lamp is shown in Fig. 21, the core, A, being drawn into the main-circuit solenoid, C, to strike the arc, whilst the differentially-wound solenoid, P, varies its pull on the core, B, according as the carbons are required to approach, to stand still, or to recede, the former action occurring when the shunt current prevails. The special cut-out mechanism, E F, will be alluded to later.

(*To be continued.*)

PHYSICAL SOCIETY.—March 23.

Prof. REINOLD, President, in the Chair.

The following gentlemen were elected members: Sir James N. Douglas, Sir Douglas Galton, Messrs. C. H. W. Biggs, C. Capito, A. C. Cockburn, R. E. Crompton, J. M. Gorham, G. C. Gümpel, W. H. Massey, E. Moynihan, F. J. Mudford, R. W. Paul, and C. E. Spagnoletti.

Prof. J. V. Jones read notes **"On the use of Lissajous Figures to Determine a Rate of Rotation, and of a Morse Receiver to Measure the Periodic Time of a Reed or Tuning Fork."** In determining resistance absolutely by the B. A., or by Lorenz's method, it is important to know the speed of rotation at the instant when the deflection of the galvanometer needle is observed. To determine this, an arm carrying a mirror is caused to oscillate by a pin placed eccentrically in the end of the spindle, and a Lissajous figure is obtained by using another mirror mounted on a vibrating reed driven electrically. Equality of period is obtained when the resulting elliptical figure is permanent, and the frequency of the reed is determined subsequently. In making the experiment it is found convenient to control the speed of the disc by breaking it, either with the finger or a piece of wood. The reed consists of a rectangular steel rod 100cm. long, and section 1·51 × ·60cm., and the length of the vibrating segment can be altered by sliding it through a clamp. To permit of this change without altering the electrical contacts, the latter are formed by two independent springs, one of which is always in contact with the rod. For determining the frequency of the reed, a second pair of contacts are operated by the vibrator, and the currents recorded by a Morse receiver, whilst simultaneously the paper receives marks from a pen controlled by a standard clock. The limit of accuracy of this part of the experiment is found to be $\frac{1}{10}$ per cent. due to changes in the reed's frequency. This is a serious defect, and the author of the paper asked for advice as to the precautions necessary to obtain reeds of constant pitch. **Prof. Ayrton,** whilst recognising the extreme importance of determining speed accurately, suggested that the inconstancy of the reed may be due to the impulse being given at the end instead of at the middle of its swing, and recalled an experiment shown before the society by Prof. Perry and himself, in which the pitch of an electrically-driven fork was varied greatly by altering the adjustment of the contact screw. Referring to Dr. Thompson's modification where two tuning-forks drive each other, it was pointed out that the method requires the synchronism of the two forks to be very exact. **Mr. Blaikley** enquired whether any doors were opened or closed during the experiments, as the pitch of a reed is affected by the size of its resonance chamber. He also stated that the pitch of reeds driven pneumatically could be maintained constant to the part in 10,000, and mentioned that two forks nearly in unison influence each other's period when near together. Referring to the two forks mentioned by Prof. Ayrton, **Prof. S. P. Thompson** said it was advantageous to mount such forks on sounding boxes, for when placed at a suitable distance apart they then exert considerable mutual control. The sketch put on the board by Prof. Jones led Dr. Thompson to suppose that a perfect method of driving forks had been devised, for two springs were shown touching opposite sides of the bar, and such an arrangement might be used to complete the circuit only when the reed is in the middle position. He also believed that forks give greater constancy than single reeds, and mentioned some recent improvements in which one prong of an electrically-driven fork is made of phosphor-bronze. **Mr. T. H. Blakesley,** reasoning from ideas suggested by Mr. Stroh's experiments on vibrating membranes, concluded that the periods of forks placed at ¼ wave length apart would not uninfluence each other. In reply to a question from Mr. F. G. Smith, **Prof. Jones** thought there could be no "creeping" of the reed through the clamp. He also stated that he had been led to use a reed from the results obtained in Delaney's system of telegraphy, and the fact that Lord Rayleigh considered electrically-driven forks satisfactory.

Dr. Hofford read extracts from the following papers:

"On the Clark Cell as a Source of Standard Currents," by Prof. R. Threlfall and Mr. H. Pollock. The authors find, contrary to ordinary ideas, that Clark cells can be used to send currents of considerable magnitude without the E.M.F. being appreciably changed, and have constructed cells which give ·001 ampere steadily for half an hour. This result has been obtained by increasing the size of the cell so that each electrode is about five square inches in area, and the internal resistance is about six ohms. For the ordinary small test tube cell, the resistance of which may be about 1,500 ohms, the current ought not to exceed ·00001. On closing the circuit the P.D. (potential difference) drops almost instantaneously to its steady value, and when the circuit is opened, rises equally rapidly to very nearly the original E.M.F. The cells completely recover in time. If the current sent be too large, the P.D. falls for a time, and afterwards rises and tends towards a fixed value. In this respect, Clark's cells are greatly superior to large Daniells sending current through the same resistance. The paper contains several tables and curves, as well as valu-

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able results respecting the close agreement between the E.M.F.'s of a great number of different cells.

"On the Application of Clark's Cell to the Construction of a Standard Galvanometer," by Prof. R. Threlfall. A large cell as above mentioned, together with a known platinoid resistance, are used to standardise a reflecting galvanometer, constructed with a single movable coil sliding in guides so as to vary the constant in known proportions. Two controlling magnets are carried on opposite sides of a sleeve sliding on a central tube enclosing the long fibre, and a small hollow copper cylinder in oil acts as damper. The tangent law was found by calculation to be practically correct up to 15deg., and the scale is curved so as to read tangents on a scale of equal divisions. To give this result, the approximate polar equation to the curve is shown to be $r = f\ (1 + 207\theta^2 + \cdot 0269\theta^4)$. In standardising the instrument, a known current is sent through it from the Clark cell, and the controlling magnets adjusted till the spot comes to a fiducial mark on the scale. By varying the position of the coil, currents ranging from 001 to ·4 ampere can be measured.

"On the Measurement of High Specific Resistances," by Prof. Threlfall. The chief points dealt with are the means for producing thin plates of material of known dimensions, the form and methods of magnetising the needles, and the arrangement of suspension found necessary when great sensibility is required. For producing the plates, two plane platinised brass slabs are used and kept at a known distance apart by micrometer screws, whilst the material is melted between them. The screws are then withdrawn, and the resistance determined by comparison with a megohm, using different E.M.F.'s in the two cases so as to obtain about equal deflections. As regards the galvanometer, after many unsatisfactory attempts to use one made according to the Messrs. Gray's pattern, the coils of that instrument were mounted in the ordinary way, and used with an astatic combination of magnetised steel discs. Extreme care was taken to obtain discs exactly similar, and a pair of electromagnets were made to magnetise them *in situ*, so as to obtain great astaticism. For suspending the magnets, quartz fibres were found greatly superior to silk, the zero of the instrument being very indefinite even with a silk fibre 30in. long. Considerable difficulty was experienced in attaching the mirror to the needle on account of the distortion produced by ordinary cements ; a slow-drying white paint was ultimately used and found satisfactory.

"On the Measurement of the Resistance of Imperfectly Purified Sulphur," by Prof. Threfall and Mr. A. Pollock. The apparatus used is described in the previous paper, the galvanometer of 16,000 ohms being arranged to give the division for 2×10^{-12} ampere. A mean of the results obtained gives about 11×10^{13} ohms per cubic centimetre as the specific resistance. In performing the experiments many precautions were required to prevent air current and magnetic disturbances, and paraffin keys were found to give much better insulation than ebonite ones. In conclusion, the authors enumerate the chief points to which attention should be paid in designing and using very sensitive galvanometers. They consider it desirable to use quartz fibres at least 6ft. long, to provide very fine adjustment for the controlling magnets, whose supports should be independent of the suspension arrangement, and believe the whole should be placed in a thick soft-iron cylinder. **Mr. Boys,** speaking of attaching mirrors to wires, said he found a very small speck of shellac varnish to be very satisfactory. As regards quartz fibres, Prof. Threlfall's method of producing them differed materially from his, and the fibres were much thicker. He considered it quite unnecessary to use fibres anything like 6ft. long, and thought 15in. quite sufficient where the weight to be supported was not large. **Prof. Ayrton** regarded the results obtained from Clark's cells to be of extreme scientific and commercial importance, for they showed that a very convenient standard of E M.F. could also be used as a standard for current. **Prof. Thompson,** after commenting on the convenience of good E.M.F. standards, expressed a hope that Prof. Threlfall would be able to suggest a convenient method for producing a standard ampere.

COMPANIES' MEETINGS.

SUBMARINE TELEGRAPH COMPANY.

An extraordinary general meeting of this Company was held on Monday at the offices, Throgmorton-avenue, London-wall, to consider and decide as to the offer of Her Majesty's Government and the Government of France for purchasing the Company's cables.

Sir Julian Goldsmid, M.P., who presided, stated that on the 16th of July, 1878, they made an agreement with Lord John Manners, who was then Postmaster-General, which, besides providing for giving to the Post Office the proportions of the receipts which were derived from telegraphic communication with the Continent, also contained this important clause : "This agreement shall take effect from the 1st of January, 1879, or so soon after that date as the French and Belgian Governments shall have granted a renewal of the concession to be applied for, and shall remain in force until the 31st of December, 1898, but no alteration of the existing tariffs shall take place unless and until this agreement shall come into operation." His predecessor, the late Sir James Carmichael, forthwith applied to the French Government to give them a renewal or extension of the concession, which would expire early in the present year. The French Government, however, on that occasion, and for three succeeding years, refused to grant the request, alleging that the application was premature. So matters went on until three years ago, when he decided on making a determined effort to put the agreement referred to into force. The Directors had negotiated with four successive Ministries, and three of them nearly came to a conclusion. The last Ministry they negotiated with was that of which M. Rouvier was the head, and he informed the Directors in writing that he was prepared to grant a renewal of the concession for ten years. On the part of the British Government, however, a diplomatic note was then forwarded to the French Government requesting the latter not to renew the concession. The Directors contended that under the agreement Her Majesty's Government had no right to make such a request, but the argument of the Government was that, as a reasonable time had elapsed since the agreement was signed and no renewal of the concession had been obtained under clause 8, they were no longer bound by an agreement which had not been put into force. The policy of Her Majesty's Government had changed, and they had determined to make arrangements by which all the telegraphic communications between this country and France, Belgium, Holland, and Germany should be in the hands of the respective Governments. The Directors considered that this decision, in view of the agreement in question, was extremely hard upon the proprietors in the Company. The Government then made arrangements with the French Government for jointly acquiring the cables between France and England and Belgium and England. The Directors had had frequent interviews with the Government, who had been requested by the French Government to carry on the negotiations on behalf of all the Governments concerned. The sum and substance of the proposals made by the Chancellor of the Exchequer and Mr. Jackson (of the Treasury) was originally that the Company should sell the French and Belgian cables at a valuation price, the valuers being appointed by the Governments and the Company, with an arbitrator, as usual, in case of disagreement. The Directors regarded this proposal as satisfactory, but, to their surprise, about three months ago they were informed that the French Government would have nothing to do with such a method of valuation, and that some other system must be adopted. Troublesome negotiations followed, it being finally decided that the Government should appoint officers to test the cables and ascertain their electrical condition, and that an offer should then be made to the Company. The result of the testing had been that allegations had been made that the cables were patched cables, and that the officer did not consider them to be in electrical condition. The Directors had pointed out that the cables did the work well, without any impediment to the traffic, and that from a business point of view they were therefore in perfect condition. [At the request of the Chairman, the Secretary then read the correspondence between the Company and the Post Office.] Continuing, the Chairman said that the Governments had offered for the four French and the two Belgian cables £22,330, or practically about 25 per cent. of the cost of laying new cables, whereas the Directors had calculated that by the worst terms of a valuation, with recourse to an arbitrator, as originally agreed to by Her Majesty's Government, the Company would receive at least 50 per cent. of the cost of laying new cables. The French and Belgian cables earned in the past half-year about £40,830, and deducting £17,000 roughly for working expenses, a net revenue remained of £23,830, or a little more than the price offered to the Company for earning it. From what he had stated the proprietors would understand that the Directors had been placed in a most difficult position. Two other cables were left to them, which were leased to other companies. If they refused the offer that had been made to them, the Governments might say that they would not have the cables at all, in which case they would only be worth their picking up value—a point which the proprietors must carefully weigh. He suggested that they should pass a resolution to this effect : "That the Directors be requested to inform the Government that, in the opinion of the shareholders, their offer of £22,330 for the purchase of the Company's cables between England and France, England and Belgium, and Jersey and France is far below their value ; that the Directors be authorised to allow the Government to work the cables on and after the 1st of April next, to continue their negotiations, and to conclude the sale of the cables to the Government at the best price they can obtain, and that the Directors inform the proprietors by circular as soon as possible of the result of their further negotiations." In his opinion, and in that of the majority of his colleagues, that was the course which it would be advisable to take. The British Government, he might point out, were taking over a great deal of property which did not concern the French Government in any way.

A discussion followed, in the course of which several shareholders strongly animadverted on the course which had been taken by the British Government.

Mr. Lewis seconded the motion.

An amendment was proposed for adjourning the meeting until Thursday, but, on a show of hands being taken, the amendment was lost, and the original motion was carried.

Resolutions were afterwards passed for winding up the Company voluntarily, and appointing Sir J. Goldsmid, the Hon. H. R. Brand, and the Secretary liquidators.

DIRECT SPANISH TELEGRAPH COMPANY, LIMITED.

The thirty-first ordinary general meeting of this Company was held on Monday at Winchester-house, Old Broad-street.

Sir James Anderson presided, and in moving the adoption of the report stated that in the half-year ended December 31 last they had carried 2,000 more messages, which, however, were composed of 27,000 fewer words. They were face to face with the natural desire of all merchants to make their telegrams as short as possible. An enormous number of messages to the East consisted of only three or four words, and a three-worded message did not pay at all. There had been a decrease of £305 in the traffic receipts compared with those for the corresponding period of 1887, the reduction being owing to the failure of the fruit trade—a circumstance which would have been more serious for them a few years ago, when the messages carried by them were all about

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fruit and shipping. Since the commercial treaty was framed the messages had been of a more miscellaneous character, and their traffic was a growing and a sound one. Since the date to which the report applied a break had occurred in the Bilbao cable. Fortunately, the Eastern Telegraph Company had a ship at Lisbon, and, in spite of very bad weather, the repair was effected in 16 days. Notwithstanding this interruption, during which they lost some traffic—though not all, owing to the joint-purse arrangement with the Eastern Company—the receipts for the current quarter had exceeded those of the corresponding period of 1888 by £250.

Mr. Edward Etlinger seconded the motion, which was unanimously adopted.

Resolutions were afterwards passed declaring dividends at the rate of 10 and 4 per cent. per annum on the preference and ordinary shares respectively, and re-electing the retiring Directors and Auditor.

NEW COMPANIES REGISTERED.

Bath Electric Light Company, Limited.—Registered by Shaw and Blake, Doctors'-commons, with a capital of £25,000 in £10 shares. Object: to adopt and carry into effect an agreement dated March 8th, 1889, made between C. J. Wharton, F. J. Down, and A. F. Davies, of the one part, and J. Chivers, on behalf of the Company, of the other part, being an agreement for a license to use and work the Thomson-Houston system of electric lighting in the City of Bath, and within a radius of five miles. The first subscribers are:

	Shares.
Major-General J. Burn, 17, Lansdown-crescent, Bath ...	1
Major-General C. A. Benson, Ormond House, Bath	1
H. G. Massingham, Claremont, Oldfield-road, Bath	1
J. Chivers, 2, New Bond-street-buildings, Bath	1
A. Taylor, 8, New Bond-street, Bath........................	1
J. Ricketts, 26, Grosvenor, Bath	1
W. Jeffery, 2, Northumberland-buildings, Bath	1

The number of Directors shall be nine, or such smaller number, but not less than three. The first are Major-General J. Burn, Major-General C. A. Benson, J. Chivers, H. G. Massingham, and A. Taylor. Qualification: not less than 100th part of the subscribed share capital. Remuneration: £50 on every £5,000 or fractional part of £5,000 of share capital or debenture of the Company, provided a 5 per cent. dividend is first earned on the paid-up share capital.

Laing, Wharton, and Down Construction Syndicate, Limited.—Registered by H. F. Kite, 11, Queen Victoria-street, E.C., with a capital of £40,000 in £100 shares. Object: to acquire certain apparatus and articles, undertakings, and installations belonging to the business carried on by C. J. Wharton, F. J. Down, and A. F. Davies, trading as Laing, Wharton, and Down, in connection with the Thomson-Houston International Company's system of electric arc and series lighting. The first subscribers are:

	Shares.
P. G. B. Westmacott, Burwell, Newcastle-on-Tyne.........	20
B. H. Martindall, Everfield, Bickley.....	10
J. Tennant, Saltwell, Gateshead.............................	5
J. T. Merz, The Quarries, Newcastle-on-Tyne	4
W. Crewdson, 60, Courtfield-gardens, S.W.................	5
E. Waterhurst, 44, Gresham-street, E.C.	3
H. G. H. Norman, 5, Southwell-gardens, S.W.	5

C. J. Wharton, F. J. Down, and A. F. Davies, or other persons constituting the firm of Laing, Wharton, and Down, shall during seven years from March 1, 1889, be the managers of the syndicate. The said firm, so long as they act as managers, are to receive, by way of office rent and salary, £500 per annum, payable by equal monthly instalments of £41. 13s. 4d. and a yearly sum equivalent to 10 per cent. of the net profits of the syndicate in each year, but not exceeding £2,000.

PROVISIONAL PATENTS, 1888-9.

November 16.

16,681A. **Improvements in and relating to multiplex telegraphy.** Francis Jarvis Patten, 77, Chancery-lane, London. (Complete specification.) (This application, having been originally included in No. 16,681, dated 16th November, 1888, takes, under Patents Rule 23, that date.)

March 18.

4,722. **Improvements in coupling devices for electric conductors.** Henry Harris Lake, 45, Southampton-buildings, London. (Albert Clark Griggs, United States.) (Complete specification.)

March 19.

4,748. **Improvements in electrical and automatic appliances and methods for manipulating aeronautic balloon batteries in conjunction with aerostatic indicating, fulminating and fumigating repeating magazine batteries, and in shells for same, for the purposes of warfare.** Wm. Howson, Bank-buildings, Sheffield.

4,800. **Improvements in electric conductors.** Henry Harris Lake, 45, Southampton-buildings, London. (Alfred Austin Brooks, United States.) (Complete specification.)

4,821. **Automatic electric induction apparatus.** Louis de Stein, Arthur Podhorzer and Franz Haver Bachmann, 38, Chancery-lane, London.

March 20.

4,846. **Improvements in electric light fittings.** Charles Krauss Falkenstein, Emile Rousseau, and Conrad Krauss Falkenstein, 265, Victoria-park-road, London.

4,849. **Improvements in insulators.** Charles Vernon Boys, 11, Alexander-square.

4,875. **An improved system for electrical transmission of power for traction purposes by direct current.** Moritz Immisch, 52, Chancery-lane, London.

4,883. **Improved apparatus for showing whether an electrical switch or contact maker is on or off.** Frank Geere Howard, 36, Cleveland-street, Fitzroy-square.

4,889. **Improvements in the generation of power for electric lighting and its application to dwelling-houses and buildings generally.** Jules Cerpaux, 33, Chancery-lane, London.

March 21.

4,901. **Improvements in means or apparatus for use in conveying electric currents for lighting or other uses.** Rookes Evelyn Bell Crompton, 55 and 56, Chancery-lane, London.

4,954. **Improvements in electrical battery cases.** Hans Fowler Price, 53, Chancery-lane, London.

4,960. **Improved means for administering electricity to, and otherwise treating, horses and other animals.** Georgina McGuire Lawrance, 45, Southampton-buildings, London. (Complete specification.)

March 23.

5,063. **Improvements in instruments for the measurement of electric currents and electro motive force.** Emil Henri Hüngerbühler and Joseph Torr Todman, 21, Finsbury-pavement.

5,066. **Improvements in sockets or holders for incandescent electric lamps.** Philip Arthur Newton, 6, Bream's-buildings, Chancery-lane, Middlesex. (Alfred Swan, United States.)

5,084. **Improvements in electric clocks with synchronising mechanism.** Alfred Julius Boult, 323, High Holborn, Middlesex. (René Pouchard, France.) (Complete specification.)

SPECIFICATIONS PUBLISHED.

1888.

3,328. **Electric contact-makers, &c.** Langdon-Davies. 8d.

4,674. **Medical galvanic batteries.** Fry. 8d.

6,214. **Laying underground electric conductors.** Farquhar. 8d.

6,322. **Galvanic batteries.** D'Humy. 8d.

7,355. **Field telegraph conductors.** Treuenfeld. 4d.

16,048. **Secondary batteries.** Thompson. (Thompson.) 8d.

506. **Electrical switches.** Lake. (Law.) 11d.

759. **Electric railway switches.** Wells. 8d.

1,343. **Measuring electricity.** Nalder and others. 6d.

1,611. **Multiplex electric telegraphy.** Dewey. 8d.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the week ended March 22 amounted to £5,670.

Globe Telegraph and Trust Company, Limited.—The Directors of this Company have declared an interim dividend of 3s. per share for the current quarter, payable on the 18th proximo.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting the fifth of the gross earnings payable to the London Platino-Brazilian Company, were £4,130.

Eastern Extension Telegraph Company, Limited.—The Directors of this Company notify a further dividend of 2s. 6d. per share, together with a bonus of 3s. per share, making a total of 6½ per cent. for the year 1888. The reserve fund has been increased by £66,101.

Humboldt Electric Power and Mining Company, Limited.—Certificates of shares in this Company are now ready for delivery in exchange for the bankers' receipts for payment of deposit, allotment, and first call, at the offices of the Company, 63 and 64, New Broad-street, E.C.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	18
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply ...	5	4½
......	...	Swan United	3½	2¾
12 July	12/0	Telegraph Construction ...	12	41½
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15½

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NOTES.

Personal.—Lord Sackville Cecil has joined the board of the Exchange Telegraph Company, Limited, as chairman.

Madrid.—A concession is being arranged for an electrical tramway of a length of three kilometres in this town.

Foreign Telegrams.—The Post Office announces that the telegraphic charge to Tunis and Algeria is reduced from 4d. to 3d. per word.

Havana.—It is announced that the electric lighting on a large scale is to be carried out in Havana. Satisfactory experiments have been made.

Paris Exhibition.—Amongst the names proposed for the technical advisers of the commission are those of MM. Hippolyte, Fontaine, Hospitalier, and Napoli. No decision has, however, been arrived at.

A Government Laboratory.—An electrical laboratory, under the control of the Government, is to be established in Berlin for the convenience of those of the public who desire to avail themselves of it.

Tenders for Electric Lighting.—The directors of the Exeter Theatre Company are inviting tenders for lighting the new theatre by electricity. Particulars will be found in our advertisement columns.

Tangier.—Dated Tangier, March 28, Reuter's Agency says: "The repairs required in the submarine cable are to be proceeded with immediately. It is not expected that any opposition will be offered by the Moorish Government."

The Telephone in Germany.—The German authorities have decided to establish direct telephonic communication between Berlin and Posen. The latter town will be connected up with all the principal garrison towns on the Russian frontier.

Civil Service Commission.—An assistant is required to the Professor of Chemistry at the Royal Military Academy, Woolwich. Particulars and forms of application may be obtained from the Secretary, Civil Service Commission, London, S.W.

A New Filament.—The Boston *Herald* learns that a Boston electrician has succeeding in making a carbon filament that will give 33 to 50 per cent. more light from the same current than the ordinary 16-c.p. lamp by its side in the circuit will emit.

Work in France.—By decree of the 19th February last, the President of the Republic has approved the contract made between the Mayor of Havre and MM. Ch. Mildé fils and Co. for the laying of electric mains in certain public thoroughfares of that town.

Santa Fe.—The telegraph lines of this province comprise 1,272 kilometres belonging to the Government, 562 to various municipalities, and 736 which are the property of private companies. There are also two telephone companies in Rosario with 2,013 kilometres of line.

Cuba.—The Municipality of Cárdenas, Cuba, have entered into a contract with the Compania Eléctrica de Cárdenas to install the electric light in fourteen streets and three public buildings. The Municipality are to pay 15,000 pesos in gold per annum for six years. At the end of that time the plant is to revert to them.

Electric Tramways.—Mr. Sellon, the engineer of the intended Chesham, Boxmoor, and Hemel Hempstead Steam Tramways, stated at a recent meeting of the Hemel Hempstead Highway Board that it was intended to commence the line between Hemel Hempstead and Boxmoor at once, and that portion of the tramway would be worked by electricity.

Harrow.—At the last half-yearly meeting of the Harrow District Gas Company, it was stated that the price of gas would be, from Lady Day, reduced 3d. per 1,000 cubic feet. It is only a simple arithmetic sum to find the amount saved by gas consumers owing to the reduction in the price of gas in various places when threatened with competition with the electric light.

St. Luke's.—At the St. Luke's Vestry meeting on Tuesday a letter was read from Messrs. Medcalf, of St. Mary-axe, stating that they were instructed by the directors of the London Electric Light Corporation to say they did intend in the present session of Parliament to proceed with their application for provisional powers with regard to their scheme.

Anglo-German Telegraphs.—On the 1st inst., the Anglo-German cables passed into the possession of England and Germany. Henceforth telegrams will be sent direct between the two countries over fourteen wires, and will be 25 per cent. cheaper—an advantage in which Austria-Hungary cannot share, as that country refused to join the convention.

The Electric Light in Spain.—A central station is about to be inaugurated at Ducango, in the province of Bilbao. The small town is to be lighted with 300 incandescent lamps. Similar projects are in view for the towns of Cestona, Azpeitia, and Azcortia (province of Guipuzcoa), where considerable hydraulic power can be utilised. Rumour is also busy with a scheme for central station lighting at Orense.

The Lighting of the City.—At the fortnightly meeting of the Commissioners of Sewers on Tuesday last, the Chairman said the Remembrancer (Mr. Goldney) had an important matter to bring before the Commission relative to electric lighting. Mr. J. V. Moore moved the communication be taken with closed doors, and this motion being carried, strangers were ordered to withdraw, and the discussion, which was understood to relate to the Board of Trade meeting on Wednesday, was taken in private.

The Electric Light and the Gas Companies.—A contemporary says: While the process of electric lighting is not so rapid as some enthusiasts had hoped, the possibility of its general adoption for domestic purposes is not overlooked by the managers of the great gas undertakings, and no efforts are spared to make rivalry an unremunerative venture. Three of the London companies are about to issue circulars offering to supply householders with all necessary fittings for the small payment of twopence per week until the whole is paid off.

Coast Telegraphs.—The Plymouth Chamber of Commerce has been pressing forward the very important project of girdling our shores with a continuous line of telephone and telegraph wires. The coasts of Norway, Sweden, Denmark, Holland, and France are already provided with a system of electrical communication, and it seem strange that we have taken no steps to do the same.

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The Plymouth Chamber of Commerce estimates that it would only cost something like one hundred thousand pounds to connect all the existing stations with the nearest telegraphs.

The Tide Utilised at Last.—There is a curious water-wheel in use at Bowdoinham, says the *Electrical World*, probably the only one of the kind in existence. It is 27ft. in diameter, with a foot of its rim out of water at high tide; the spokes are wide and set diagonally, like the vanes of a windmill. It turns 18 hours a day by tide-power—running one way with the flow, the other with the ebb. With one foot fall of the tide the wheel is said to give about 50 h.p. Here is an hint, says our contemporary, for electrical engineers. The hint has been given often enough; we are glad to welcome its practical performance.

Animal Magnetism, or Suggestion.—Dr. Pinel, of Paris, has succeeded in hypnotising several subjects by means of the phonograph. All the commands given through this channel were as readily obeyed as those uttered directly, and "suggestions" of every possible sort were as effectually communicated through the medium of the machine as if made *viva voce*. The conclusion deduced by Dr. Pinel is that the theory of a magnetic current passing from the operator to the subject is entirely baseless, and that the real cause of the phenomena of hypnotism is nervous derangement on the part of those subject to them.

The Electrical Omnibus.—The electrical omnibus left the depot of the Ward Electrical Car Company, Limited, on the morning of the 2nd inst., at 9.30, and ran to Euston Station. Some of the directors and manager of the Liverpool Tramways Company were awaiting it, with Sir George Baden-Powell, M.P., and Mr. Houlding, the chairman of the Sanitary Committee of the Liverpool Corporation. The omnibus returned by way of Euston-road, Great Portland-street, and Regent-street, to the company's depot at James'-street, Haymarket. It came through the crowded traffic with perfect ease, and without exciting any alarm.

Coal Combination.—A correspondent to one of the gas contemporaries points out that the suggested coal combination would act disadvantageously towards the gas companies. He points out that they are endeavouring to develop the supply of gas for cooking and heating purposes as well as for lighting, and that all this progress in favour of coal consumption will be thrown out of gear by the combination. He acknowledges that they have two formidable foes to compete with, both of which are making considerable headway—viz., electricity and oil. We are glad to see such acknowledgment, and trust that the competition between electricity and gas will become considerably keener.

One Million Capital.—Rumour is again busy. We hear that Westinghouse is desirous of floating a company in London with a capital of £1,000,000. If such is the case, and we heard it on very good authority, it should bring its lesson with it. There is every appearance of a boom on the face of it, and unless Westinghouse leaves £250,000 of his own capital in the concern to ensure its bona fides, investors would do well to be cautious. We still hold to our contention that no competition over given areas should be allowed. Such a course is likely to end in disaster for all concerned, and once more sacrifice a deserving industry to the insatiable greed of the company-monger.

A Useful Publication.—We have received a work in pamphlet form by Belloc Luigi (G. Bruno and Co., Turin) entitled "Terminologia Elettrica," a vocabulary of electrical technical terms in Italian, French, German, and English. It is really a vocabulary of those technical phrases for which dictionaries are usually consulted in vain; and, as it is carefully compiled, it will be found of great use to those whose inclination or business lead them to peruse foreign technical literature. Its range of usefulness would, however, be extended if four editions were published, so that the four languages could be alphabetically arranged. It would then become a technical dictionary which could from time to time be amplified.

Testing-Room Practice.—It has always been understood that during the conduction of testing operations with low currents and sensitive apparatus, such, for instance, as cable-testing with an astatic galvanometer, the operator should stand upon some insulating substance, such as a sheet of vulcanite or indiarubber. It is now suggested by one who has had a great deal of experience in this direction that not only should this practice be departed from, but that the body of the operator should be effectively connected with an earth of small resistance. The chief reason alleged is that the human body accumulates charge accidentally received up to three or four microfarads, and is liable to very considerably disturb the electrical conditions of the testing circuit.

The Central Telegraph Office.—In the House of Commons, on the 27th ultimo, in answer to a question by Mr. Lawson, Mr. Raikes stated that the actual charge in respect of first-class telegraphists at the Central Telegraph Office for the current financial year could not yet be precisely stated, but it would be less than the estimate. Since the estimates of the expiring financial year were framed, an addition had been made to the establishment of the Central Telegraph Office, and the authorised number of the first class at the present time was 363. In this class of 365 persons there were on the 31st of January last 53 vacancies. To 34 of these promotions had been made within the last few days; and this, practically, was an answer to the petition of December.

O.S.A.—An ordinary general meeting of the City and Guilds of London Institute Old Students Association will be held on Wednesday, April 10th, at 7.45 p.m., at the Central Institution, Exhibition-road, S.W. (Committee meeting at 7 p.m.) The following paper will be read: "Photo-Mechanical Printing Processes," by W. F. Bourne, member. The paper is divided under the following headings: (*a*) Methods of producing intaglio plates; (*b*) methods of producing zinc or relief blocks; (*c*) photo-lithography; (*d*) Woodbury type; and will be illustrated by various specimens and blocks in various stages of production. The second number of the journal has been issued, and contains, besides other matter, Mr. Heller's paper on "Aluminium," and Mr. Albion T. Snell's paper on "Electromotors." In consequence of the rapid sale of this number a reprint has been necessary. Copies may now be obtained, price 7d. each, postage included.

Typical Cable Faults.—As affording some information relative to the behaviour of faults in submarine cables, the following note is not without interest: The fault was made in type C cable by the grapnel, while being raised to the bows, on the 5th of December, 1878, off Capes Villano and Finisterre. The depth varied from 100 to 300 fathoms. In hauling in the cable no strain was observed on the

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dynamometer, but when the grapnel came to the bows it was found that a very few fathoms of cable hung upon it. The picked up piece tested as follows: End polarised more quickly with Z than with C, and showed a higher resistance with the negative current. The exposure was $1\frac{3}{16}$in. The lowest resistance, C to line was seven ohms. The lowest resistance, Z to line was 40 ohms, highest 200 ohms. The guttapercha was very much drawn. The conductor was broken off short; the ends clean and of uniform length. The sheathing was broken 6in. from end of core.

Electro-Deposition on Glass or Porcelain.—Recent experiments have demonstrated the possibility of depositing metals upon glass or porcelain by means of electricity. The process, which is ascribed to M. Hansen, is thus briefly described: "The great difficulty was found to be that of giving a conducting surface to the glass, because the medium, being no longer susceptible of removal once deposition had taken place, had necessarily to be of such a nature as not to weaken the adhesiveness of the deposited metal. The medium used is a solution of chloride of gold, or of platinum in sulphuric ether, which has received a sufficient quantity of sulphur dissolved in a heavy oil, to bring the whole, after being gently boiled, to a consistency which permits it to be painted on the glass, etc., with a brush. The plate is then slowly heated in a furnace until the sulphur and chlorine are driven off, leaving the gold or platinum adhering to the surface. The plate can then be treated in the ordinary manner.

The Electric Traction Company.—We are informed that there is absolutely no foundation whatever for the so-called "strange rumours" concerning the Electric Traction Company, Limited, and Messrs. R. E. Crompton and Co., Limited, of which the *Electrical Review* professes to have been "credibly informed." The Barking-road installation is now very nearly completed, and the cars have been running this week, and as soon as everything is in thorough working order, the regular service of the North Metropolitan line between Canning Town and Green Gate will be taken over, and worked entirely by electrically-propelled cars. Our contemporary's note was as follows: "*Strange, if True.*—There are strange rumours afloat respecting the position of the Electrical Traction Syndicate. First of all, we are credibly informed that a big company is about to be registered to work the system; and later we hear that Messrs. R. E. Crompton and Co., Limited, have taken the whole thing over. Which is correct? The same report was current respecting the almost defunct Elieson Company and Messrs. Crompton, so it is possible that the latest rumour has about as much truth in it."

Chelmsford.—The decision of Chelmsford is in favour of electric lighting. On the 25th February tenders for lighting by oil, gas, and electricity were considered by the Lighting Committee of the Council, which resulted in the committee recommending a contract with Messrs. Crompton and Co. for five years. This contract was for 20 arc lamps and 72 incandescent or oil lamps, subsequently modified to 110 incandescent and no oil, at a cost of £700 a year. The tender of the gas company showed a reduction of about £100 as against their price of last year, and it may be noticed here that the gas company has taken competitive action, and reduced the ordinary price of their gas by 2d. per thousand feet. The Council had this report before them several times, and some months ago decided to call a public meeting to discuss the matter. This meeting took place last week. After a somewhat stormy discussion, in which all manner of hard things were said about electric lighting, it being asserted that it was almost an entire failure, the proposition was carried "That this meeting is of opinion that the recommendation of the committee be carried out—viz., that the Council be requested to accept the tender of Messrs. Crompton and Co. for the public lighting of the borough." At the meeting of the Town Council on the Wednesday following this meeting, the question was again freely debated, and it was finally resolved to accept the tender of Messrs. Crompton and Co.

The Indian Telegraph Department.—The annual report of the Indian Telegraph Department during 1887-88 shows that a considerable increase took place during that year in the number of miles open, the number of messages sent, and in the receipts. The most important event was the transfer to the department of the Indo-European Telegraph Department. The Indo-Siam route is said to have proved almost valueless. The total length of line open at the end of the year was 93,743 miles, representing 93,517 miles of wire and 226 miles of cable. During the year there was an increase in the total length of 6,657 miles, representing 6,627 miles of wire and 30 miles of cable. A large portion of the wire lines are worked by railway companies, there being no less than 33,043 miles of wire in connection with the various railway systems, and much of the increase in the total length of line noticed above was caused by the opening up of new lines or the extension of existing ones. In Burma, the work has mainly consisted in consolidating and strengthening existing lines. Communication between Upper Burma and Assam has been established by the completion of the line from Manipur *viâ* Tammu and the Chindwin Valley. This line runs from Mandalay to Ava, where a cable crosses the Irrawadi and connects it with Sagain. From thence it is carried across country *viâ* Myinmu to Moniwa, where it meets the Chindwin, and follows the valley up to the junction of the Yu river, after which it follows that river to Tammu. The connection of Upper Burma with India by this route has been attended with considerable difficulty, and the staff employed suffered much from hardship and exposure, which brought on fever and malaria.

Brussels.—The programme for the organisation of a system for the distribution of electricity, adopted by the Common Council of Brussels at a meeting held on the 25th ult., is briefly as follows: Proposals will be received up to the 1st of next July for the establishment and carrying out of a system of electrical distribution, by underground mains, for lighting purposes, for motive power, and other applications of electricity. The competitors will be required to formulate their proposals in such manner as to assure for the first installation at least 10,000 16-c.p. lamps in an area mentioned in the proposal. It should also be stated upon what terms competitors are prepared, should the Council so desire, to extend the lighting beyond the limits laid down. The concession will be for a maximum period of 18 years, but the Council reserve the right to take over the installations after three, six, or nine years, as well as after the expiration of the concession. The terms should be distinctly stated for each one of these periods. The price per 100 watts-hour must be given for (1) private lighting and (2) public lighting generally. Other conditions are, the amounts of the rental to be paid to the State and the caution money to be deposited. The proposals must be

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drawn up in the clearest possible manner, indicating all the conditions upon which intending competitors are willing to accept the work. The two following clauses should be inserted: The authorities shall at all times have access to the establishments of the concessionaire; the contractor shall be deprived of his concession if it be decided that the work done by him is not efficient. Judgment upon this point to be passed by three experts; one nominated by the Council, one by the contractor, and the third by the President of the Tribunal of the First Instance.

Electric Light in Germany.—The following list of towns in Germany lighted by electric light is given by the *Bulletin de L'Electricité*, and illustrates the progress made in central station lighting in that country. Over 16,000 h.p. is employed in these stations, more than half of which is for Berlin alone:

Towns.	System.	h.p.	Mains.
Barmen	3-wire and accumulators	600	underground.
Berlin:			
Markgrafenstrasse	„	3,900	„
Mauerstrasse	„	2,000	„
Spandaustrasse	„	2,000	„
Dorothienstrasse	„	2,000	„
Brunswick.	„	2,000	„
Bremen	3-wire	600	„
Breslau	„	500	„
Cologne	„	500	„
Darmstadt	3-wire and accumulators	450	„
Dresden	„	500	„
Eberstadt	„	100	„
Elberfeld	3-wire	325	„
Ems	multiple series	100	overhead.
Frankfort	„	1,000	„
Gorlitz	„	450	„
Halle	„	550	„
Hamburg	3-wire	1,200	underground.
Königsberg	„	300	„
Lübeck	„	300	„
Majbeburg	„	500	„
Mulhausen	„	300	„
Olmütz	„	300	„
Strasburg	„	400	„

A large number of these stations have already begun considerable extensions to their plant in addition to these figures. It is noticeable that not one of these stations uses the alternate current system, and that nearly all the mains and feeders are placed underground.

Ship Lighting.—Messrs. W. H. Allen and Co., of York-street Works, Lambeth, have just completed the lighting of a large passenger vessel, built by Messrs. Laird Bros., Birkenhead, for the Compania sud Americana de Vapores. The vessel, named the "Imperial," is one of 2,000 tons burthen, propelled by engines of 4,000 h.p., and is specially built for the trade between Callao and Valparaiso. The boat is fitted with the most modern appliances, and the saloon is lined with maple and satinwood, beautifully ornamented with carvings, and luxuriously upholstered. The electric light has been provided for every part of the ship from the masthead to the coal bunkers, and employs over 230 glow lamps of the Edison-Swan type. The signal lights are considerably stronger than can be provided by the best oil lamps, and are so fitted that oil can be substituted, if needful, at a moment's notice. Special brackets are provided for loading purposes. In the engine-room, bunkers, and holds plugs have been inserted so that the current may be tapped, and a powerful light concentrated in any given spot for temporary purposes. The elegant electroliers for the saloon and social hall have been designed to suit the fittings and furniture, and are adapted both for oil and electricity. The lamps exposed to rough usage are enclosed by damp proof bell glasses, and these are protected by strong wire cages. Cockburn's slate switches and fuse-boxes have been used throughout, each state-room being separately connected. The conductors branch into six circuits from a six-way slate switchboard, and a second board, with the main fuses, and fitted with a voltmeter, is placed on the return circuit. All the wires are enclosed in wood casings. The "Kapp" dynamo is compound-wound, and capable of feeding the whole of the lamps at the low speed of 280 revolutions per minute. It is driven direct by an Allen twin engine, at a steam pressure of 160lb. The engine and dynamo are so fitted as to work without vibration, and no sparks are visible at the brushes. The installation has been superintended throughout by Messrs. Allen's electrician, Mr. J. W. Kempster, and gave universal satisfaction on the trial.

Printing by Electricity.—As has already been remarked, a new departure has been taken in the printing of newspapers, which we think is likely to be largely adopted in the future. On Saturday before last the formes of the *Star of the East* (the evening edition of the *East Anglian Times*) were placed on the Wharfdale machine, which had been geared to a motor in connection with 50 E.P.S. accumulators. The *East Anglian Times* says: The current from the batteries was turned on and the motor at once began to revolve rapidly. A belt from it drove the printing-machine just like a steam-engine, but instead of an engine with a great flywheel, occupying a considerable space, the whole electric motor was not bigger than a barrel churn. Its driving pulley was only 9in. in diameter. There was no smoke and no noise, no need of a man to attend to it. Yet the power generated was ample, and directly the handle of the Wharfdale printing-machine was turned copies of the *Star* began to fly off with great rapidity. All the machines in the room—two printing and two folding—were, for a trial, run simultaneously by electricity, and went at a rattling pace. It was curious and instructive to change from this noisy scene to the small storage room at Messrs. Laurence, Paris, and Scott's central station, where the batteries did their invisible work. There seemed to be a moral lesson about the experiment, that the noisiest agents are not always the most potent. In London and all places where room is valuable, electrical motors would possess many advantages over steam. The whole apparatus can be contained in a closet, dispensing with cumbrous engine, boiler, and chimney-shaft. Then, again, no time is lost in getting up steam, but an immediate start can be made, and directly the work is done a knob is turned and the current from the central station cut off. For intermittent work electric motors must, therefore, be admirable and economical. There are occasions again, rare no doubt, when the use of steam is itself impossible. On the breaking-up of the frost a fortnight ago the main of the Ipswich Water Works burst, and about midnight our engine-driver arrived with a woeful face to tell us that the printing would probably have to be stopped for want of water. Electrical power in reserve would in such, and many another, emergency be of great value to the printer of daily papers, who cannot afford to wait a minute. A breakdown to him of a few minutes is equivalent to the loss of a day. The credit of the performance, which is simplicity itself, says our contemporary, belongs to Messrs. Laurence, Paris, and Scott, and to their Ipswich manager, Mr. Sisling.

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ELECTRIC WIRING OF BUILDINGS.*

BY J. D. F. ANDREWS.

The first points for consideration in devising a wire system for electric lighting are, what contingencies will be met with that will affect the system, and what faults will arise in it after its introduction.

Throughout past experience it has been found that the practical pressure of electricity for electric lighting is, within 50 per cent. either way, about 100 volts—the 100 volts being most generally adopted. The chosen conductor is copper, and the most widely adopted insulation is indiarubber in many modified forms; the insulated conductors are usually protected and held in position by wooden casing. We need hardly question the object of the conductor, but what is the object of the insulation? The conductors if held in good dry wood casing only would be protected from interference. Its object is to meet one of the worst contingencies—moisture or water—which is an ever working evil on electric light wires. If you place a copper wire in water with electricity passing along it, the copper will be removed electrolitically from the part of the wire where the electricity enters, and deposited where it leaves. The same process goes on where uninsulated or badly insulated electric light wires lie in water or surrounded by moisture. Even though no electricity is flowing through a copper wire exposed to moisture and the atmosphere, it is acted upon chemically. The result of the electrolitic and chemical actions on electric light wires is to thin them and make them insufficient for carrying the current, and consequently they become heated. Or the result may be that the wire is eaten through when an electric arc is produced. This effect or fault is called an opening circuit, and is about the most difficult and dangerous fault to contend with. It is usual to lay the electric light leading wire in a groove in the casing neighbouring and parallel to the return wire. Water often saturates the casing between them, and when the insulation is poor, the electricity will pass through the moistened wood and char it, often setting it in flames. Faults such as this where a great leak is taking place between the wires are called partial short circuits, and are equally difficult to avoid and as dangerous as opening circuits. The study of the insulation of the wires is therefore obviously of great importance. Most of the results in good insulation were obtained by telegraph engineers before the electric light business was started, but in the new businesses these results were almost entirely ignored. Great insulation was then not considered necessary. Special covering for the wires was devised of a cheap and poor quality, which, it is greatly to be regretted, has continued in use by many contractors to the present day. As previously stated, indiarubber is the base of the insulation of most electric wires, the purer the material the better the insulating properties; but pure indiarubber is easily influenced by air: at first it gets hard, and in course of time changes to a soft, sticky state, when it is useless as an insulation. Pure indiarubber is still the foundation of insulation on the wires, but in the very best qualities it is protected from the atmosphere by an outer coating of what is known as vulcanised indiarubber. Such qualities of insulation consist of first one or two lappings of pure indiarubber, then a layer of indiarubber mixed with such minerals as soapstone, over which again is laid a coating of rubber mixed with a large proportion of sulphur. The wire, with its three coatings, is now subjected to a high temperature in a vulcan by means of steam, through which the rubber and sulphur combine, while any surplus is absorbed by the middle coat, which is called the separator. Such is the insulation of the best quality wires; the inferior qualities and those most generally used are insulated simply with pure rubber and cotton serving, with ozokerite or other compound tape laid together in many different ways, according to the device of the makers. The compound tape is supposed to protect the pure rubber from the air, but it only plays this function to a small extent. The usual reliable life of such wires is from two to three years, and not being reliably waterproof throughout their length, at any time there is always danger of failure through moisture. Vulcanised indiarubber covered wires of the class above described—there are many inferior kinds—is perfectly reliable in water or air for a great number of years. The next contingency that has to be contended with is mechanical damage. The wires being more or less flexible and the covering soft, they are easily damaged. This difficulty is usually met by casing the wires in wood, and it being necessary to employ two conductors for electric lighting—the casing has two grooves, one for each conductor—a cover being fixed over them. Wood casing has the disadvantage of harbouring moisture. Another method of protecting the wires is that of sheathing them with an outer covering of wire as introduced by the writer some years ago in ship lighting. This method protects the wires much more effectually than casing and does not harbour moisture. Iron pipes have been used in many cases, and are an excellent protection; but moisture collects in them, and if there should be a fault in the insulation, it is sure to find it. There is another fault besides the opening circuit and partial short circuit not yet touched upon—namely, a dead short circuit, or a direct contact between the opposite conductors. This is the most frequent fault, and if it were not that there is a simple appliance called a fuse to meet it, it would also be the most dangerous fault. Short circuits usually happen in the fittings where the opposite conductors are necessarily brought nearer each other, and at these points the insulation is generally much thinner and poorer. Short circuits also often happen where the wires cross, and frequently by contact with gas or water pipes, which make very complicated faults because the two wires usually touch the pipes a distance apart, which will be better understood by reference to Diagram 1. Suppose the current to leave the dynamo by the positive wire, pass to the lamps by the branch wire and back by the negative branch wires through the fuse, F, and the negative main to the machine. Suppose now the positive branch becomes connected to a gaspipe at, say, A. This would not indicate itself in any way, and the installation would of course continue working just the same until the opposite wire got connected to the gaspipe, say, at B. Now the current will become excessive, more than the branch wire can carry without getting dangerously hot, before the main fuse, T, melts. In the above description it is assumed there is a safety fuse at F, but it will be observed the short circuit has bridged the wire in which it is inserted, and it is consequently useless to avoid the excessive heating of the wires with such faults above referred to. It is necessary to have fuses, one on each wire, such as at F and S. Under such circumstances, when a short circuit, such as described, between A and B takes place, the fuse, S, would immediately blow and prevent danger. Let us again assume there are fuses on only the negative wires, we will see there might have been even a worse fault. Again, supposing a connection at A with the gaspipe, which is, of course, connected to the earth, we will assume the second connection to take place in the dynamo field-magnets at C. The current will now traverse the positive wire to A, thence to the gaspipe to earth, and back to the dynamo. This route is a short circuit, and one, moreover, that bridges both branch and main fuses, which we have assumed to be only on the negative wire, as is still the practice of some contractors. The consequence of this short circuit is similar to the one from A to B, but worse, because there are no fuses at all left to protect the system. Of course, with another main fuse on the positive wire, such a short circuit could not continue. There is, however, objection to the multiplication of fuses. They are a danger themselves sometimes, such as in the case of a partial short circuit that does not increase the current sufficiently to melt the fuse, but quite sufficient to heat it to a degree dangerous to any inflammable material in the neighbourhood; and it may continue in this condition some little time before it fuses, especially if it is a large one. Another point of danger from a fuse is when it melts it throws out sparks of molten metal. Of course, it will be said that the evils in fuses can be reduced by proper construction. That is true; but it is decidedly better to avoid, if possible, numerous points of danger in an installation resting on special construction or the care of an attendant for their prevention. We will consider later how this to a certain extent can be

* Paper read at the Philosophical Society of Glasgow.

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achieved. In the foregoing we have considered mainly the contingencies or dangers arising with the introduction of electric light into buildings, and we may summarise the main points as being an opening circuit, a partial short circuit, a dead short circuit, and the fuses. We have considered the dead short circuit to be met by the fuse, although a new element of danger is introduced, which, however, is much less in degree. This new element of danger can be reduced to one-half by connecting one of the leading wires—say the positive to the earth and the gas and water mains, it being only on account of the latter that it is otherwise necessary to provide a fuse on each wire. Diagram 2 will show this more plainly: The current leaves the dynamo by the positive terminal, and meets at once a connection to earth, and the gas and water mains then proceeds by the positive wire to the lights and back to the dynamo. This connection to earth is wilfully effecting the

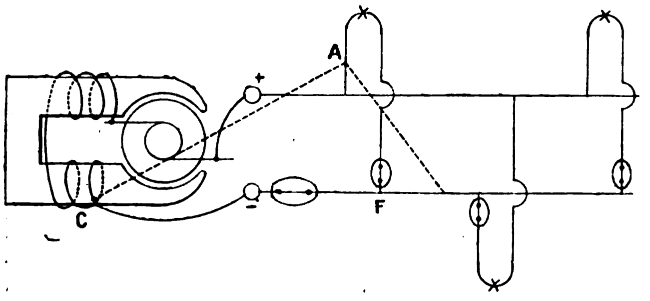

Diagram 1.

fault we supposed might happen, as in diagram 1. But in making the connections to earth we are careful to do so with that wire which has not got the fuses inserted in it, which is contrary to the action of the fault in Diagram 1. Now, if any of the negative wires come in contact with the gas and water pipes, a fuse must instantly blow as if their two conductors themselves had touched. All the electric light fittings would in this case be connected with the positive wire, the negative wire passing down the centre of the tubes. There being in the fittings only a single wire, which can be heavily insulated and made stouter, there is an additional safety against short circuits and fuse melting, besides the very great advantage of being able in a very simple way to wire each part of an electrolier or fitting. Diagram 3 illustrates how this is effected. The current travels from the contact, A, down the wire B, through the contact, C, to the switches, S, S, by the wire D, to the lamps, L, and back by the brass of the fitting to the ball and socket at the top, and away by the earth wire. The wire inside the tubes is never smaller than No. 14 S.W.G., and the contacts are made with a strong small

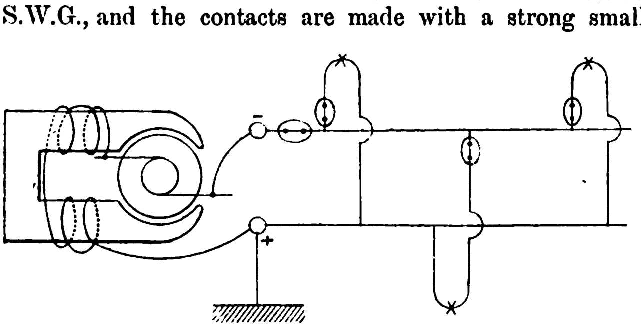

Diagram 2.

spiral spring. The contact at the ball and socket joint projects through, and, being a box spring, it gives and takes with the swing of the fitting, and scrapes on a fixed brass plate in the roof plate. Single or universal joints are quite simple to construct with this system within the same dimensions as for gas; whereas with the two wires passing through the fitting such is impossible. This method of connecting one of the wires to earth is best called the earth system. It is, however, often called the single-wire system, because in its applications to ships the hull of the ship is used as the return wire. In buildings, however, two conductors are required, and, as it is important always to be able to distinguish between the negative wire, in which the fuses are inserted, and the positive wire, which is connected to earth and all the electrical fittings, the positive wire is coloured red, and the negative wire black. The object for connecting the positive wire to earth is that red-coloured wires are usually inferior in insulation quality to black wires, and it is not so important that the return or earth wire should be so highly insulated as the leading wire. We now come to the consideration of means for minimising those most dangerous faults, opening and partial short circuits. Except the means proposed by the writer in the following paragraph, no attempt has been made to treat these faults, except by good workmanship and material. The proposal

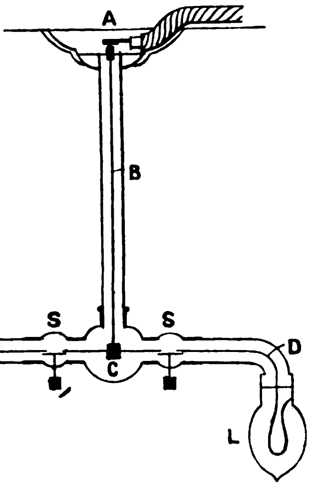

Diagram 3.

the writer makes is to universally adopt the sheathed or armoured wire system devised by him some years ago for use in the exposed and damp places on board ships using the earth wire system, and now extensively used for that purpose. The virtue of this system is that all

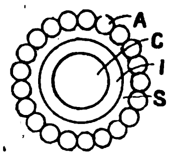

Diagram 4.

faults, partial short circuits and opening circuits, are reduced to dead short circuits. Diagram 4 is an enlarged section of an armoured wire such as is now in use. The pink portion C is the copper conductor; I is vulcanised indiarubber insulation of the highest class, with

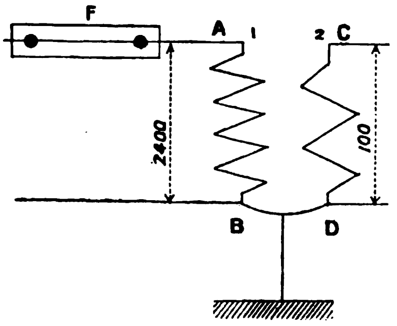

Diagram 5.

a serving of jute and special compound between it and the iron armouring, A, which is a great many times larger in cross-section than the copper conductor, care being taken that it is always more than seven times larger, this being about the difference in electric conductivity of the two metals. It will be understood that the copper wire is the lead, and the iron wire the return. It was assumed in devising this system that an opening circuit in the outer conductor was very unlikely to take place, and so it has been found in practice. It is, however, possible that the inner conductor, through undue strain or a flaw, might have an opening circuit in it, and if such were to take place, the immediate result would be that the heat generated would destroy the insulation between the two conductors, and at once effect their fusion together and a short circuit. As a matter of

fact, however, short circuits in this system have in practice been many fewer, and there have been no opening circuits or partial short circuits. How many of the short circuits were due to such faults is difficult to say—the causes of some were doubtful.

The writer is not aware of any new danger or contingency being introduced with this system of concentric wiring, although he has heard that some people object to it, and, in fact, any system in which an earth connection is introduced; but he has still to learn upon what grounds the objection is based.

In addition to the advantages above referred to, there is another of not the least importance. The electricity being entirely enclosed within the outer conductor, and the electric pressure being only from the centre point to the outer conductor, it is impossible to get a shock through anything more than a very small portion of one's flesh, such as the finger end, except by wilful contrivance.

It is advisable, before closing this subject, to consider how a system of wires supplying a town would be affected by an earth connection of one of the conductors. With any system of supply embodying the series system, I may generally say it is not advisable to employ an earth. I have expressed this point broadly, as it involves complex considerations which would take long to make quite clear. But with all systems on the parallel system, there are many points favourable to an earth connection, some of which can be gathered from foregoing descriptions. It is more important for us to find out whether there is any objection to its use, and with this in view Diagram 5 is placed before you. It illustrates a transformer with its primary leads, and an electric pressure of 2,400 volts at the terminals, A and B, where they join the primary circuit 1 of the transformer. F is a fuse in the primary circuit. 2 is the secondary circuit of the tranformer between the terminals, C and D, of which there is represented a pressure of 100 volts. The terminals, B and D, of the circuits of the transformer are connected to earth, and consequently connected together. The writer is unable to find any danger in thus connecting the 100-volt pressure circuit to the 2,400-volt pressure circuit. Nobody could get a shock to earth, because the pressure between the return wire and earth is reduced to nil. The next point is, is there any greater probability of the insulation of the transformer breaking down because the circuits are joined together at one end? This seems to the writer to be answered by a simple calculation. With the earth connection there is no pressure at one end, but all the pressure, whatever it is, at the other. With no earth connection the pressure is alike at both ends, but at each it is only half the total. The result in both cases is the same. Suppose a connection did get made between the terminals, A and C, in addition to the earth connection, why the 2,400-volt circuit would be simply short-circuited, and the fuse, F, would melt. There is, it is true, a very remote possibility of danger in the event of the great improbability of three circumstances happening in succession—viz., first of all, a connection between the terminals, A and C, as well as the earth; then, the fuse, F, not melting; and, thirdly, the circuit of the secondary of the transformer to open between the terminals, and thus put the 2,400 volts pressure on to the lamps direct, which would, as a matter of course, immediately gasp their last.

There is one other circumstance worthy of mention in favour of the earth connection. Should the wire system at any time be struck with lightning, there is at once a safe connection to earth. Instead of having to pass through a highly-insulating material as when there is no earth connections, lightning has already been known to strike overhead electric light wires, and discharge itself through the dynamos to earth, to the imminent danger of the machine.

USEFUL ELECTRICAL QUESTIONS FOR TROPICAL CLIMATES.

(*Concluded from page 256.*)

With regard to our third question, it had reference to the practical usefulness of platinum-silver coils in hot, humid climates; it being also remembered that the instruments are invariably located on the seaboard. We did not, and do not, wish to dispute the fact that platinum-silver and platinum-iridium alloys, on account of their compactness and small variability, are infinitely superior to german silver for home or continental work. If anything is wrong, it can easily be remedied, or the instrument exchanged. Spare apparatus is at hand or is readily obtainable, and no great inconvenience is likely to result if a coil should happen to develop a fault There are many things, mechanical and otherwise, however, whose constitutions but ill-adapt them for prolonged sojourn in hot countries. Our esteemed contemporary, the *Electrical Review*, says platinum-silver coils are reliable, "provided the silk covering of the wire is *well* dried at a high temperature, and the coils are *afterwards* saturated with hot, pure paraffin wax, so that moisture is excluded and not bottled up, there will be no error through polarisation." This opinion we are ready to endorse. But there is an *if*, and the question is to what extent this *if* qualifies the practical usefulness of platinum-silver coils, such, for instance, as are supplied to foreign cable stations? Perhaps Messrs. Elliott Brothers could give us the desired information?

What we want to get at is this. Certain data and certain apparatus are supplied to cable stations for the guidance and use of electricians and superintendents at those stations. Are those data and apparatus thoroughly trustworthy? We wish to obtain expressions of opinion from those practical workers abroad who have hitherto been dumb, and who, so far as we can see, are not represented in the world of letters. The platinum-silver resistances of which we have mostly had experience are: (1) 100,000ω, boxes made up of 40,000, 30,000, 20,000, and 10,000ω coils respectively; (2) slide resistances; (3) Wheatstone bridges and resistances of the dial pattern. They were all of Elliotts' manufacture. If we describe what happened at one cable station, and add that it was by no means an isolated case, our readers will see that there is some method in our madness.

The station was provided with the following testing apparatus:

Four 10-micro condensers.
One ⅓ " "
One 100,000ω resistance-box.
One shunt-box.
One dial-bridge and resistance.
One astatic galvanometer.
Batteries, etc.

The H. R. dials and shunt-box were of platinum-silver, and had been in use for about three years. Distance from sea about 50 yards. Average temperature from sunrise to sunset 28deg. C.

On inspecting the register of tests, curious discrepancies both in the C. R. and insulation resistance were noticed, and the apparatus was overhauled to discover the reason. The 1,000ω coils of the dial resistance were first tested—ratio 1,000-1,000—and came out as follows:

1. Usual way :

1,000ω = 1,001·3	6,000ω = 6,009
2,000ω = 2,001·1	7,000ω = 7,009
3,000ω = 3,000·3	8,000ω = 8,009
4,000ω = 4,002·4	9,000ω = 9,010
5,000ω = 5,002	10,000ω = 10,011

L King plug in—

9 and E = 1000	5 to 4 = 1000·3
9 to 8 = 1000	4 " 3 = 1000·6
8 " 7 = 1000·4	3 " 2 = 999·8
7 " 6 = 1001	2 " 1 = 1000
6 " 5 = 1000·7	1 to zero = 1001·2

Bridge Reversed.

Coil 1 (usual way):

1,000ω = 1,002·4	6,000ω = 6,017
2,000ω = 2,003·5	7,000ω = 7,019
3,000ω = 3,004·3	8,000ω = 8,020
4,000ω = 4,006·8	9,000ω = 9,023
5,000ω = 5,009	10,000ω = 10,023

The 1,000-1,000 ratio tested all right so long as the 10,000-10,000 was not used for some time previously. The 10,000-10,000 ratio was all wrong, and it was found that the coil on the cable side acted as a secondary cell, in-

fluencing the 1,000 coil nearest to it inductively. Charged for 30 seconds with 18 volts, it gave a discharge of 0·014 volt. Tested as a condenser, its capacity was 0·0627 micro.

The following details may be of interest:

Plugged out all other coils of balance and charged faulty coil for one minute with 18 volts. Then disconnected battery and observed with 10,000ω shunt on galvanometer. Immediate discharge 230 divisions:

1	min	185	fall	45		6	min	115	fall	7
2	„	160	„	25		7	„	106	„	9
3	„	144	„	16		8	„	99	„	7
4	„	132	„	12		9	„	93	„	6
5	„	122	„	10		10	„	87	„	6

On examination the spool was found to be badly fractured at the base, and one end of the coil—although making contact with the standard—without solder. The 1,000 coils of the dial had in every case projecting ends (bare wire) ½in. to ¾in. beyond the soldering.

The H. R. behaved in a still more extraordinary manner. Tested by bridge, 1,000-10,000.

(1) It gave
95,877·3ω corrected to 28·8c

(2) By Sir Wm. Thomson's (capacity) method,
97,350ω

(3) By deflection method,
D through 10,044·8ω (corrected) shunt 5ω = 356
d „ H R „ 50ω = 387
= 91,789ω

and it required 8,000ω (roughly) more in circuit to reduce *d* to D.

(4) By deflection,
91,347ω

(5) By deflection,
90,972ω.

The box was then left until the next day, when it showed a residual charge of 10 divisions on an unshunted galvanometer. The 20,000 coil was then charged for one minute with 18 volts and observed.

Immediate discharge = 6 divisions.
After 1 minute = 2 „

Charged 30,000ω coil as above.

Immediate discharge	= 350 divisions.		
After 30 seconds	= 190 „	fall	160
„ 1 minute	= 155 „	„	35
„ 1·30 seconds	= 140 „	„	15

Charged 40,000ω coil.

Immediate discharge off scale,			
After 30 seconds	= 300 divisions.		
„ 1 minute	= 270 „	fall	30
„ 1.30 seconds	= 255 „	„	15
„ 2 minutes	= 230 „	„	25
„ 2.30 seconds	= 215 „	„	15
„ 3 minutes	= 208 „	„	7

The 10,000ω coil showed no residual charge, but was low in value.

The box was then earthed for ten minutes, and the inductive effect of each coil upon the other coils tried, but no such effect was observable. But even after the ten minutes' earth, the coils gave deflections representing a remaining charge of:

30,000 coil = 40 divisions
40,000 „ = 70 „
20,000 „ = 2 „

These eccentricities on the part of the H.R. made, as may be readily imagined, a considerable and variable difference in the calculated absolute insulation resistance of the cable, variable because D varied with the condition (a condition depending largely upon the humidity of the atmosphere) of the H.R. at the time of observation. In practice the discrepancy amounted to 25 per cent.

After making experiments with coils in which the retentive effects given by the coils of the H.R. were reproduced, it became evident that the phenomenon was due to dampness. The coils were therefore carefully examined and found to be quite free from paraffin wax in several places. They were then subjected to a heat sufficient to evaporate moisture without injuring the insulation or the soldering, and reparaffined at a high temperature. Under this treatment the retentive effect finally disappeared.

Now, german silver, although it has a higher coefficient, is not open to this objection, and it is a question whether for tropical climates it is not better to make the coils of this alloy. Platinum-silver coils require not only to be very carefully made, but to be carefully treated. We have seen the cases containing testing apparatus lying for many hours in the blazing sunlight. The resistance-boxes are in some places placed periodically in the sun *to dry* before commencing to test, and so on. The fault is not necessarily, though probably, with the maker. All these things have to be considered, however, and therefore we have asked our readers in the tropics to tell us what they think of the questions we have proposed.

THE TRANSMISSION OF POWER BY ELECTRICITY.*

BY FRANK J. SPRAGUE.

The transmission of power by electricity is now an established fact, and every day, for the ordinary uses of life, its application is rapidly spreading. The principles of its application are well settled. The dynamo and motor have been brought to a remarkably high efficiency and leave little to be desired as converters of energy. The future of the transmission of power from central stations, under ordinary conditions, is a matter of commercial development. The special application of the transmission of energy over long distances depends chiefly upon the demand which exists for such transmission and the intelligent application of principles already well known. Distance is a relative term. It does not seem a difficult matter to transmit 5 h.p. ten miles, but a gigantic problem to transmit 1,000 h.p. one mile; the latter appeals to our imagination, and yet the former is, in one sense, the more difficult problem, not so much because of any difference in the general principles involved, as in the fact that in the construction of machines of high E.M.F. we meet with more serious difficulties in the matter of insulation and the element of personal danger to the operator.

It is not my intention to enter into any general discussion of the question, nor to go into the particulars of dynamo and motor construction, for the limits of this paper would not permit this; but I shall briefly point out the different phases which the transmission of power by electricity may assume, show some of the general conditions which must be met, emphasise the practicability of such transmission, and then more particularly discuss a new method for the determination of the elements of a single transmission which my own practice has brought out, and which I have found it advisable to adopt. I shall here consider only the use of a continuous current and a direct transmission.

For the purpose of this paper, we may consider the following cases of transmission:

1. Transmission from a central station conveniently situated near the centre of a manufacturing district, over an area of from 1 to 100 square miles, in units varying from a fraction of a horse-power to 50 or 100 h.p. Such a system is illustrated by the Edison two and three wire circuits in operation in a large number of cities in the United States. Referring to my own work alone, its practicability is illustrated by the fact that in Boston I have nearly 150 motors in operation, in New York about 125, and in New Orleans nearly 100; there being in various stations not less than 1,200 machines, varying from ½ h.p. to 30 h.p., and used in no less than 130 different industries. These machines are operated under potentials varying from 100 to 440 volts, and are run on constant potential circuits. The maximum distance in this class of work is, at present, about one mile on 220-volts circuit, and the practical limit for this potential from a single station is about four square miles.

In considering how far this central station work can be carried, we must bear in mind certain facts; power transmitted means the transference of an energy whose value may be expressed, as in all cases of fluid transmission, by the product of the quantity and pressure—that is, by the product of the E.M.F. and the current. With any given amount of energy transmitted, the E.M.F. and the current will vary inversely. The laws of distribution are clear. With any given work done, loss on the line, E.M.F. at the terminals of the motor, and distribution, the weight of the copper will vary as the square of the distance, its cross-section, of course, varying directly as the distance.

* A lecture delivered before the Franklin Institute, November 12, 1888.

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With the same conditions, the weight will vary inversely as the square of the E.M.F. used at the motor. With the same cross-section of conductor, the distance over which a given amount of power can be transmitted will vary as the square of the E.M.F. If the weight of copper is fixed with any given amount of power transmitted and given loss in distribution, the distance over which the power can be transmitted will vary directly as the E.M.F. Hence, if it is practical to economically transmit power one mile under 200-volts pressure—that is, if the investment in copper is not disproportionate—then, by increasing our pressure to 800 volts, we can transmit this power four miles without changing the ratio of the investment. Of course, I am now speaking of the use of a bare wire and assuming that the cost of stringing the four miles of given weight of wire is no more than stringing an equal weight one mile. Of course, this is not strictly so. As a matter of fact, however, it is a practical thing to transmit and deliver over an area of 100 square miles, from one central station, under a pressure not exceeding 1,000 volts; and the larger the amount of power distributed and the greater the number of units, the more cheaply it can be done. The question arises, "Would it be economical, in a district of this character, to deal with the larger horse-powers?" My answer is unquestionably, "yes." It is true that the actual efficiency of double conversion would vary from 50 to 70 per cent., depending upon the distance and the pressure used, but experience has developed the fact that not over about 35 to 40 per cent. of the maximum capacity of all the machines in a circuit represents the average duty demanded; and since this is so, it follows that the amount of power that can be contracted for will at least equal, probably considerably exceed, the steam-power in the central station. I say "steam power" because in a large majority of cases in this kind of transmission steam, and not water, will be the prime source of energy. When we consider the economy of operating a large, well-designed, and properly constructed steam plant, and the great advantage to the user where the electric motor replaces the ordinary steam engine, it does not need a very shrewd commercial sense to see the advantages of this method. In fact, there is not a city in the United States, no matter how numerous its factories, which could not have them run better than to-day by a well-constructed electrical plant, working under pressures which would not be dangerous to life.

2. Somewhat analagous to the system we have just discussed is the transmission at constant potential, with the motors applied with various loads at constantly varying points. Such a system of transmission is that which exists in the parallel circuit system for railroad work. There are now in the United States alone no less than 60 or 70 electric railways in operation or under construction. The most extensive of these, up to the present writing, is the Richmond Union Passenger Railway, whose characteristics may be cited as an illustration. This has about 12 miles of track, and is operated under a pressure of about 450 volts. The central station has a capacity of about 375 h.p. The farthest point reached is about three and one-half miles from the station. The equipment consists of 41 cars, with 82 machines whose aggregate normal capacity is between 600 and 700 h.p., nearly double the steam capacity. The car units develop anywhere from nothing to 20 h.p. The maximum load which has been put upon the system at one point at any time is the starting of about 22 cars about two miles from the station, requiring, probably, about 125 to 150 h.p. This road now having made nearly 600,000 miles, the practicability of this kind of transmission may be accepted as an assured fact.

3. The transmission from one station to another, at which latter point are a number of independent machines, each of which has a variable load, and is required to run at constant speed. An example of this is the transmission from a water-power to a stamp-mill, where the different batteries of stamps are operated by independent machines. The most satisfactory method is to maintain at the receiving station a constant potential, and to use for the receiving machines motors wound to be self-regulating, according to laws which I gave some time since. The dynamos should either be compound wound, or the field regulators adapted to increase the E.M.F. of the machine as the load increases. Constancy of prime speed is an essential, or if it does not exist then there must be a combined mechanical and electrical governor which will assure a definite E.M.F., which shall correspond to each variation of the current.

4. The transmission between two stations as last mentioned, save that the condition of automatic regulation is not essential. In this case the dynamos may be either shunt, compound, or series wound, and the motors either shunt, cumulative, or series. Such a plant is now running in one of the mines at Aspen, Col. The E.M.F. there used is about 450 volts and the distance somewhere about a mile.

5. Transmission with a single line over a long distance, with the motors distributed throughout the entire line. This is a case which may occur in some manufacturing districts, but is more apt to occur in such work as canal building, dredging, or mining in river beds. It can be accomplished by the use of a constant current circuit, using constant current motors, or with the same aggregate E.M.F. on a constant potential circuit. A marked case is the mining operations carried on at the Big Bend Tunnel of California, in a large river canyon, where about a dozen machines, developing from 5 to 10 h.p., are used for operating pumps and derricks, and are supplied by two lines of from 600 to 1,000 volts potential over a distance of about eight miles from the central station.

Thus far I have considered the distribution with a practically constant potential at the motors, and the parallel method of distribution, as distinguished from the constant current method, where the motors are in series. This last, for large powers and many machines, is a limited and unnatural method, the former a comprehensive and natural method, which facts are entirely independent of the question of relative electrical potentials or currents, because, on constant potential circuits, we can work at 100, 1,000, or 5,000 volts if we choose.

Among some of the special cases of power transmission I will briefly note the following:

6. The transmission from one point to another, using two series-wound machines, where the motor has a constant torque or a load per turn. The motor being at rest, as the E.M.F. of the generator is raised by increasing its speed, or by increasing the resistance of a shunt around its field with any given speed, the current, which may be expressed by

$$\frac{E}{K}$$

will increase until the torque is great enough to start the motor against its load, when the current will become stationary. A motor E.M.F. being now created, the current is expressed by

$$\frac{E' - e}{K} = \frac{E}{K},$$

Any increase of the E.M.F. of the generator will be followed by an equal increment in the motor E.M.F., the difference between the two, and hence the current, remaining perfectly constant. The speed of the motor being known for one E.M.F. and load, its speed for any other E.M.F. may be determined, and fast or slow hoisting be regulated entirely at the generating station.

7. The transmission to one point from another with a single generator and a single motor with variable loads presents two solutions. The first is the use of the compound dynamo and differential motor; but a far more interesting solution is the use of two series machines, which, when properly proportioned, become perfectly self-regulating. I will briefly touch upon the theory of this method of transmission. We have the condition that the same current passes through each field and armature, and also the condition that the speed is constant, while the work is variable. Since work may be expressed as a product of speed and torque, and since the speed is constant, it follows that the motor torque must vary directly as the work. Again, we have as an expression for the work done the product e C. Since the speed of the motor is constant, e must vary directly as the strength of the field, which, where the magnetisation is low, will vary directly as the current, and when more highly magnetised in a much less degree. E being E.M.F. of the generator and K the resistance of the circuit, we have—

$$C = \frac{E - e}{K},$$

and, as we have already stated,

E varies as e, as $E - e$, as C,

and work,

varies as e C, as C^2, as e^2, as E^2.

The dynamo, likewise, being driven at a constant speed, E likewise varies as the strength of its field. If m equals the number of turns of wire in the dynamo field, and n those in the motor field, then the ampere-turns or magnetising forces are expressed by m C and n C. It follows from what proceeds that the magnetisations due to m C and n C should vary in the same proportion; in other words, the characteristics of the generator and the motor must be similar between the limits of the variation in load. Should the machines used be improperly proportioned, then the regulation can be largely determined by putting a resistance in the line circuit, or shunting one or other of the fields with a resistance. The electrical efficiency of the circuit being

$$\frac{e}{E},$$

we have the following fact: That the electrical efficiency is a constant for all loads with the limit of automatic regulation. If the machines are of the same general type, then, when correctly proportioned, the ratio of their weights and watt capacities should be the same as the electrical efficiencies of the circuit.

(To be continued.)

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

COMPANIES AND COMPETITION.

Once upon a time, *vide* the tales of the Arabian Nights, we heard a well-known gentleman speaking of a reform, or series of reforms, he heartily desired, say that no opportunity should be allowed to pass without urging the necessity for such reforms. It is merely a statement of fact to say that individuals cannot undertake central station work—that is, the general distribution of light and power to a whole town, or a whole district of a very large town. An individual or a private firm may initiate such distribution, but the limits of their work are soon reached. The wisest plan to obtain the necessary capital, and the necessary interest in the work, is to promote a local company, in which the shares are held by local people, the consumers of the light and power. With certain reservations, we are altogether against the introduction of what may be called foreign capital. By this we do not mean the introduction of French, German, or American capital, but rather that London speculators and capitalists should not find money for local companies in country towns. There is a move in the right direction when we find Taunton, Bath, Bournemouth, Brighton, etc., favouring purely local companies. The electrical industry, so far as the distribution of light and power are concerned, has much to learn from the history of gas companies. These have been eminently successful companies, and not altogether because of being monopolies. It is almost silly to suggest the possibility of the successful existence of two small gas companies in a small town. Some people who cry out for unrestricted competition, ask for it for different reasons. The buyer of the product wants to buy at the cheapest rate, and he thinks competition just and right. The great capitalist, looking far ahead, sees a way of making competition pay. Shareholders have to bear the loss, and to make this as small as possible sell out at the best price they can get. A long period of no dividends, and with future prospects with competition somewhat gloomy, means a succession of shareholders selling out at a lower and a lower price—each losing a little, and not liking his loss. The wily capitalist buys largely at the low rate, gets a controlling interest, amalgamates the competing companies, and pockets thousands. Our friends in America are great adepts at this kind of thing, and we venture to think the lessons they have taught are not falling upon barren ground in England. At the end of the game the public laugh because they have been gainers, the prime movers in the scheme laugh because their pockets are filled to repletion. The only sufferers are the early shareholders, about whom no one cares, as they are expected to look after themselves; but, looking at the whole business from an economic point of view, a lot of good money has been thrown

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away. A large part of this may be saved if the system of local companies is followed. There should then be no great waste. The local people can judge better than outsiders as to their real wants, and can see whether under the conditions promised these are likely to be supplied. Then, again, they are gainers from the best possible point of view, in that they are producers of their own goods. Deducting the percentage necessary for carrying on the business, we contend that they get their wants supplied at about cost price, and more than this can no man desire. Let us explain more fully, and take, say Bath, as a concrete example. The local company to be formed at Bath asks for a capital of £25,000. Suppose the residents who want light and power subscribe this capital. They obtain the light and power at an agreed-upon price, and subsequently, if the price is properly arranged, get a dividend. This dividend, we take it, really acts as if the price of the light was obtained at a lower rate. A local company, whose shareholders are users of the goods manufactured, is really a co-operative concern under another name, and there is no known method of production more economical than this. We, of course, assume that the business is conducted in the ordinary fashion by reputable men. In every case, therefore, when a bona fide local company is promoted it has our heartiest sympathies for its success. When we come to deal with London the case is different. No local company can be formed to supply such a huge place, and, according to all the signs of the times, competition will take place till the weakest goes to the wall in each area. Once more we say the shareholders are to be pitied. As will be seen from our other columns, the enquiry referred to in our last issue has commenced, and the first text dealt with is this very one of competition. The wealthiest company, according to the first day's evidence, favours it, but no doubt further evidence will be given on the other side. Even at this early date we hear of rival companies canvassing the same people—one company fixing a time for supply and losing the order, another taking the order, wiring the place, and not fixing a time for supply, rather leaving it to be inferred that the supply can be obtained at once. Other companies are prospecting the same district, and no doubt will canvass the same people. Be it remembered, too, that competition cannot be restricted to two companies, but must be free to all. And so we may see half-a-dozen contiguous houses supplied by half-a-dozen different companies. Each company, of course, will claim the same facilities for laying mains, and, if carried to extremes, the result of unrestricted competition will be disastrous. We earnestly ask those who are so eager to get to work to pause before their action leads to almost irretrievable confusion, and by such forethought adding to the great possibility of future success.

CORRESPONDENCE.

ELECTRIC LIGHTING IN LONDON.

To the Editor of The Electrical Engineer.

Sir,—From a letter which recently appeared in your columns, it appears that the Board of Trade has under consideration a number of applications for provisional orders under the provisions of the Electric Lighting Acts in respect of areas within the metropolis.

Now, in considering these applications the Board of Trade will no doubt have due regard to the interests of the public, and in so doing will especially keep two ends in view—namely:

1. To minimise the serious inconvenience which must arise from the laying of mains and the consequent disturbance of the roadway during that process, especially if concurrent powers are granted within the same area to rival companies.

2. To obtain for the public the lowest possible price compatible with efficiency in respect of the electricity to be supplied.

Hitherto it seems to have been assumed that it is necessary that the company which contracts for the supply of electricity should also own and lay down the mains along which the electricity, when generated, is conducted to the consumer. It is, however, a matter for serious consideration whether it is necessary to assume this.

Is there any reason why the local authority which controls any given area should not itself own and lay down the mains necessary for conducting electricity to a point within the reach of the private consumer? Assuming that such a step were taken by the local authority, it would be easy for such authority to invite tenders from the various electric supply companies for the supply of the required amount of electricity along the mains owned by the local authority, and to charge the company whose tender is accepted a rent sufficient to cover interest on capital expended in laying down and depreciation of the mains.

The advantages of such a plan are obvious. The roadway would have to be disturbed once, and once only. The local authority would control the electric lighting within its own area, and be in a position at any time to take advantage of the most efficient and cheapest system of electric lighting.

A similar problem has already presented itself for solution in the case of gas, water, and tramway companies.

In the two former cases the local authorities failed to move in the matter at the outset, and the result has been high prices during the existence of the monopoly, and the payment of heavy sums under the head of goodwill when the local authorities have at length taken into their own hands the various undertakings.

In the case of some tramways, however, the local authority (*e.g.*, in Manchester and Liverpool) has taken the initiative, and itself laid down and owned the tram-lines, and the results have fully justified them in this course.

It must not be forgotten that a system of electric lighting which is to-day cheap and efficient, may, after a lapse of twelve months, be dear and obsolete.

You will, I am sure, be doing a public service by opening your columns to a discussion which may tend to a solution of a difficult problem of grave importance.—Yours, etc.,

April 2, 1889. H. S. H.

THE LATE C. H. B. PATEY, C.B.

It was with very great regret that the many friends of Mr. Patey heard of his death last week. The sad occurrence took place rather unexpectedly on the Thursday afternoon at his residence, South Lawn, Bickley, and the funeral took place on Tuesday last in the presence of a large number of friends. Charles Henry Bennet Patey was a son of the late Admiral C. G. E. Patey, C.M.G. He entered the Post Office at the age of 19, as a clerk in the secretary's office, in the year 1863. Shortly afterwards, Parliament sanctioned the working of telegraphs by the State, and throughout the arduous work which fell upon the Post Office

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for some years, in effecting the necessary purchases from telegraph and railway companies and in organising the new service, Mr. Patey rendered valuable assistance, and attracted the notice of his official superiors by the energy and ability with which he discharged his duties. In 1877 he was appointed Assistant-Secretary to the Post Office, and in 1882 the late Mr. Fawcett promoted him to the post of Third Secretary. Thus during the last 12 years Mr. Patey has taken an active part in the management of the Post Office, the general superintendence of the telegraphic service being specially in his charge. When, in 1881, the newly-introduced telephone was judicially declared to be a telegraph, it became Mr. Patey's duty to conduct the delicate negotiations with the telephone companies, which resulted in defining their relations with the department. A little later, sixpenny telegrams were authorised; and to Mr. Patey it fell to place the service on a footing to enable it to cope with the vast increase in the number of messages to be transmitted. Up to the very moment of his last illness he was busily engaged in the pending negotiations and arrangements in relation to the purchase and working of the Submarine Companies' cables. He represented the country from time to time at meetings of the International Telegraph Congress, and on the conference relating to the protection of submarine cables, and conducted frequent negotiations with the Continental Governments on the subject of international telegraphy. There can be no doubt that the strain of work, which was always increasing, and in which he took an intense interest, told on Mr. Patey's strength. About five years ago he suffered from a very severe attack of inflammation of the lungs, and, although his recovery appeared to be complete, his constitution had probably been enfeebled. Mr. Patey was at work at the Post Office up to the end of the week before last; but on the Sunday he was pronounced to be suffering from a return of his old complaint. His condition was not, however, considered to be in any way critical until very shortly before his death, when the action of the heart was found to be failing. He was in his forty-fifth year, and leaves a widow and five sons. Mr. Patey was a vigorous and able administrator, and his loss will be felt in the department which he so zealously served, while those with whom he worked will long miss and lament the genial and manly comrade struck down in the prime of life. Mr. Patey received the distinction of the Companionship of the Bath in the year 1886, on account of his services to the State. Not only can the highest praise be meted out to the late Mr. Patey in his official capacity, but his many personal friends will acknowledge that whatever words of praise may be given can never adequately represent the true state of the case.

ARC LAMPS AND THEIR MECHANISM.*

BY PROF. SILVANUS P. THOMPSON, D.SC., M.I.E.E.

(Concluded from page 262).

A much simpler pattern of lamp has been several times described with various modifications in detail by Jaspar, 1878; Romanze (3901[81]), Andrews (3393[82]), and lastly by Menges, 1887, whose form is shown in Fig. 22. Here the long core, S N, is drawn up into the solenoid, wound differentially with a coarse wire, A, and a fine wire winding, B. A heavy piston of metal on the top of the upper carbon-holder, *d*, serves both to counterpoise the weight of the core, and to check, as it slides in the surrounding tubes, any too sudden movements. It is often claimed for solenoid lamps that the absence from them of all mechanism renders them superior to all other species of lamps. Yet they are not free from defects; they do not always burn steadily; some of them have the evil habit of "pumping"; and so simple a matter as the elongation of the cord which connects the plungers may put their regulating properties to confusion. In a recent modification by Doubrava the iron cores are fixed, and the solenoid coils slide up and down over them, giving motion to the carbons.

The *screw-feed* lamps have been already touched on. Of these, the most successful in practice is the Cance lamp (3976[81]), which operates by the weight of the upper carbon. The screw is prevented from turning by a nut gripped until feeding is necessary. In Siemens' holophote lamp (6987[87]), and in Maquaire's new lamp (1889), the mechanical turning of the screw forces the carbons forward.

Amongst *magnetic clutch*-lamps the Gulcher lamp, as improved by the Gulcher Company (Whiteman, 1915[82]), still holds its own. In this lamp the single counterpoised horseshoe electromagnet—with unequal limbs—sticks itself on by one pole to the iron carbon-rod, and by the other pole attracts itself upward to strike the arc. For constant potential work it is a very steady lamp. More recently, magnetic clutch-wheels have been used by Dittmar (1886), and by Trott and Fenton (6910[84]).

Motor-lamps have been devised from time to time, those of Tchikoleff, Schuckert, and Gray being perhaps the best until recently. The latest lamp of this type is that of Maquaire (1889). In this lamp there is a Pacinotti ring upon a vertical pivot, on which a worm is cut. This gears into a large wheel, the pinion of which drives the upper carbon-holder by a rack. The motor ring stands between the pole-pieces of

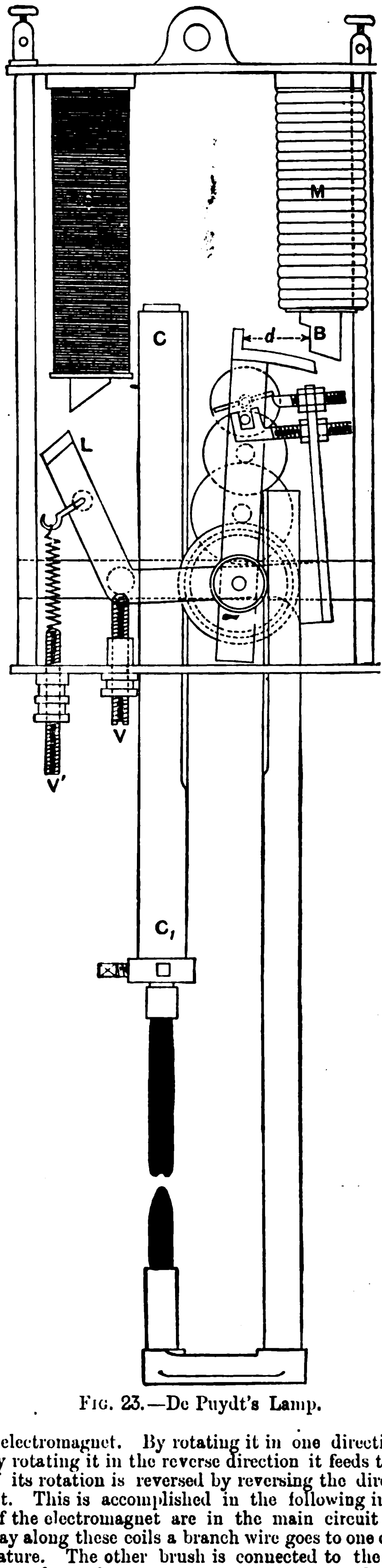

FIG. 23.—De Puydt's Lamp.

a powerful electromagnet. By rotating it in one direction it strikes the arc; by rotating it in the reverse direction it feeds the arc. The direction of its rotation is reversed by reversing the direction of the current in it. This is accomplished in the following ingenious way. The coils of the electromagnet are in the main circuit; and from a point midway along these coils a branch wire goes to one of the brushes of the armature. The other brush is connected to the tongue of a sort of relay, and stands between two contacts, one of which goes to one end, the other to the other end of the coils on the electromagnet. By raising or lowering the tongue the armature is thus connected as a shunt, either to one-half of the magnet-coils or to the other, the current in it being in opposite directions in the two cases. The tongue of the relay is controlled by a separate shunt-coil, which attracts the

* Paper read before the Society of Arts, March 6th.

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tongue in order to feed the arc. The feed action of this lamp is extremely delicate.

It would be impossible, in the scope of this paper, to dwell on the *hydrostatic feeds*, on the various modes of producing *vibrating feeds*

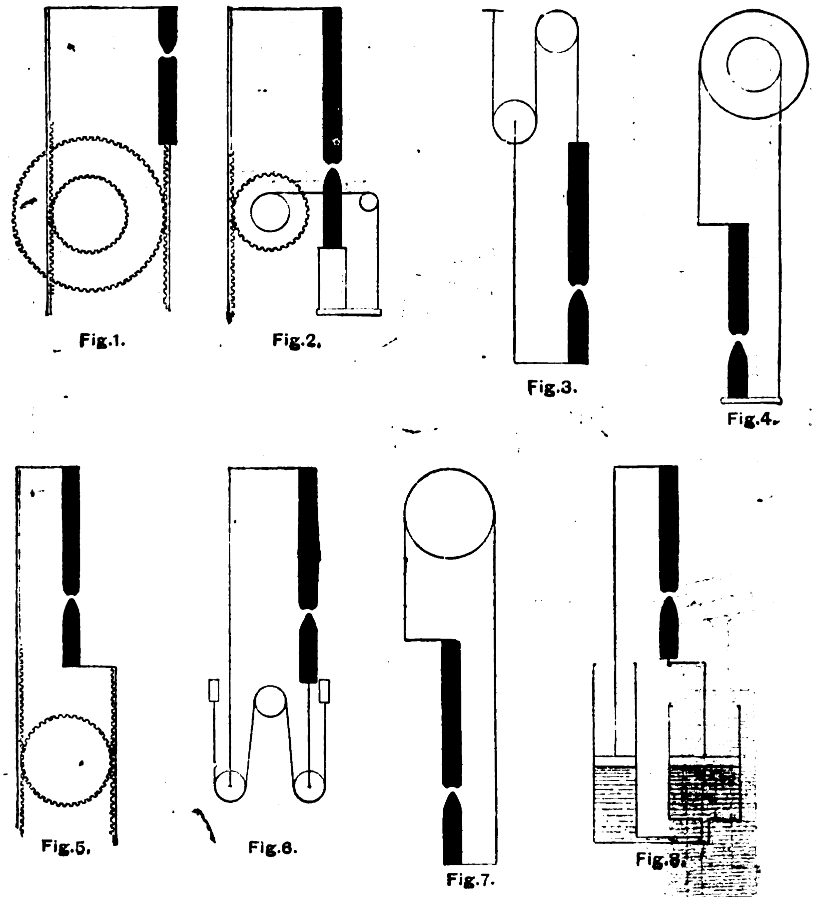

FIG. 24.—Modes of Focussing.

and *hammering feeds*, which have been from time to time suggested. The notion of having a *continuous* feed, the rate of which should be varied as required, is an enticing one, but it has never been made a

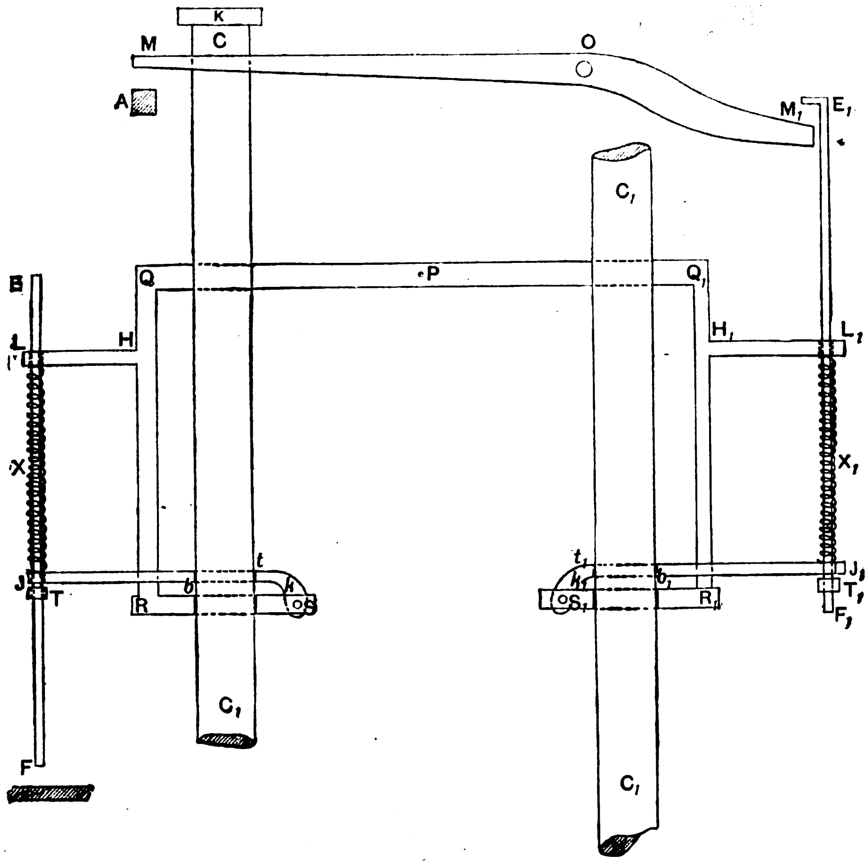

FIG. 26.—Mechanism of Thomson-Rice Lamp.

practical success. Neither have the periodic methods of feeding, at which Mr. Brockie made so brave an attempt in 1881; the flavour of which indiscretion still clings about him in spite of the admirable lamps which he has produced in later years. Mr. Brockie's various forms of arc lamp would indeed well illustrate the whole range of the subject, and the same thing might be said about the numerous successive types of lamp produced by Mr. Crompton. Mr. Brockie has lately produced an excellent little projector lamp for use in the optical lantern, having the negative carbon pressed by spring against abutment screws of steel, whilst the upper carbon is fed forward by a nipping-lever controlled by a solenoid. *Abutment* lamps and *projector* lamps form separate classes by themselves, which cannot here be discussed.

Many of the points alluded to in the preceding descriptions are illustrated by the action of the De Puydt lamp, Fig. 25. This is a

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rack-train lamp which strikes its arc by lowering the lower carbon and raising the upper simultaneously, and feeds with a fly and detent controlled by a shunt-magnet. The main-circuit magnet, M, attracts obliquely its armature, rocking the train of wheels around the pivot of the first wheel. A lever, L, bent to an elbow which rests on the set screw, V, is also pivoted around the same arbor, and has a vertical arm which carries two attachments; a fork which engages on a pin on the train-frame, and a detent which arrests the fly. The other end of the lever, L, is held back by a spring, but can be attracted up by the shunt-magnet, S, when the detent is to be released in order to feed,

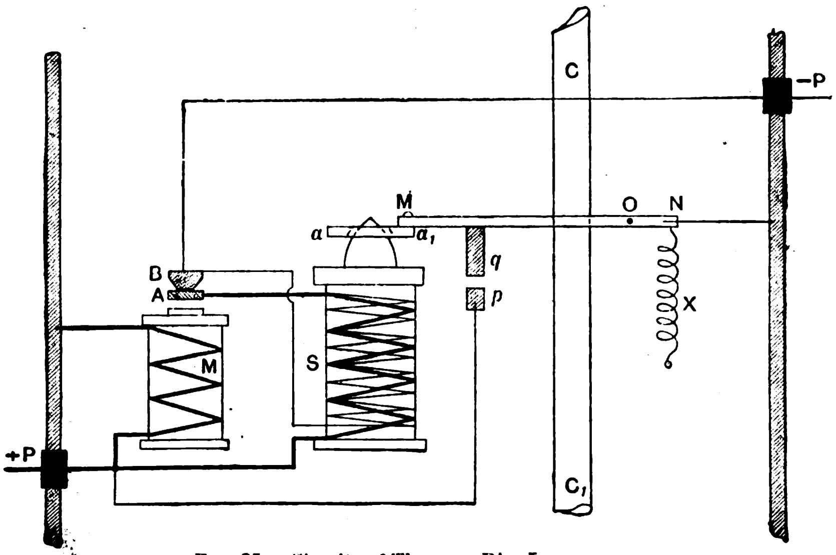

Fig. 25.—Circuits of Thomson-Rice Lamp.

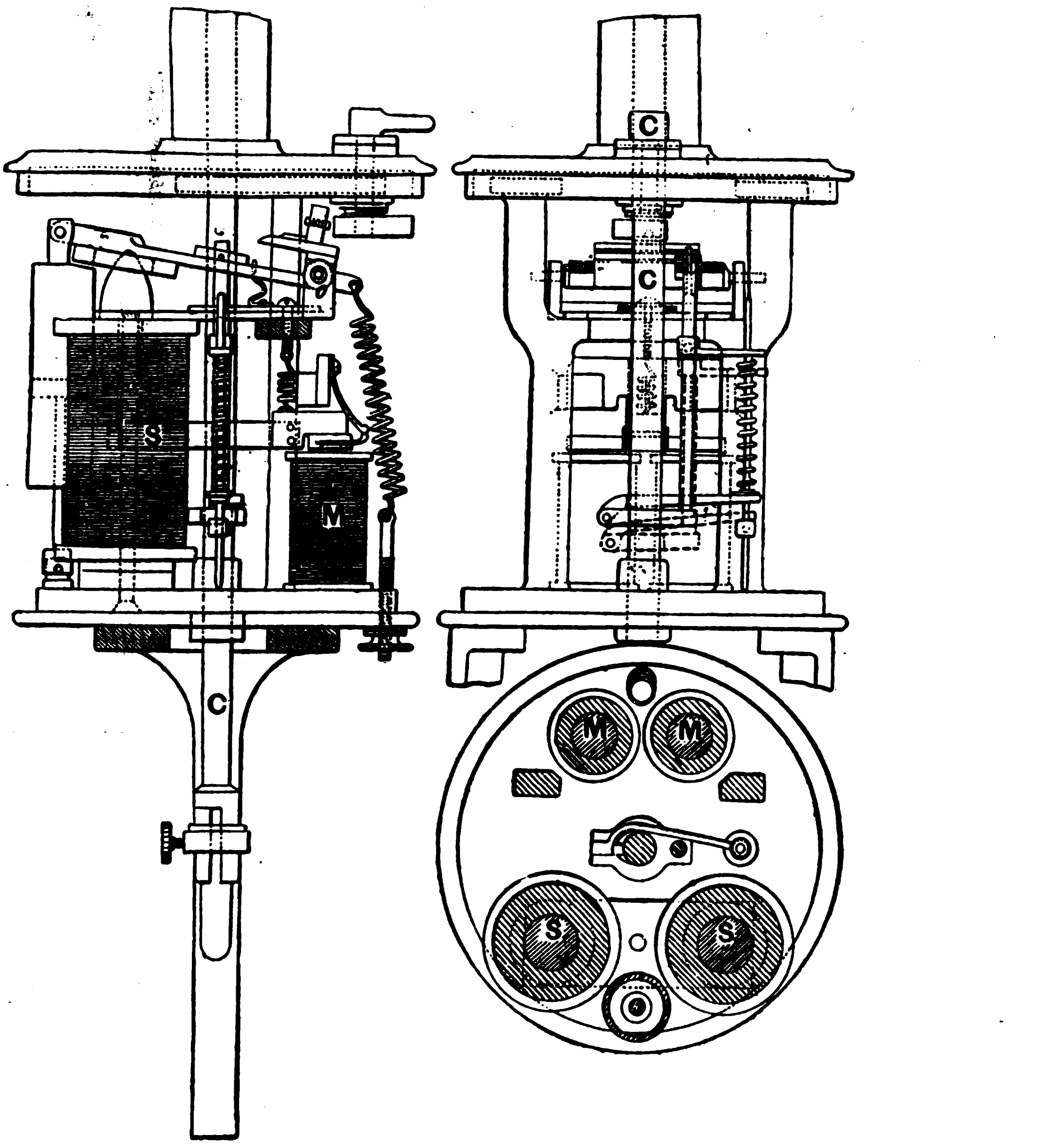

Fig. 27.—General view of Thomson-Rice Lamp. M. The cut-out (or cut-in) electromagnet which opens the contacts of the coarse-wire winding on the electromagnet, S. S. The principal electromagnet, wound with fine and coarse wire. The armature of this electromagnet is attached to a lever pivoted at O, and held at its other end by a strong spiral spring. This armature, in sinking, opens the clutch, and, in rising, closes it on the carbon-rod, which it raises.

Product-Regulation.

Before passing away from the feeding mechanisms, we may return to the question of regulation in general, and in particular to the point that the function of the mechanism of the lamp is to maintain constant one of the two factors of the electric energy, the dynamo being responsible for the other. That part of the electric mechanism which controls the feed is responsible for the steady working of the lamp; and it is this which has to be sensitive to the fall of the current (in constant potential lamps), or to the rise of the potential (in constant current lamps). It is this which must control the feeding mechanism

of the lamp. It may be remarked that the striking electromagnet represents the muscle of the lamp, but the feeding electromagnet represents the brains. Now, if the brains of the lamp have to think about, and control, one factor in the product, why can they be not made to think about and control the product itself? Such a lamp, in which the controlling part is neither an ampere-meter (main-circuit) device, nor yet a voltmeter (shunt) device, but a wattmeter device, ought to make the lamp independent of any fluctuations in the supply. Product regulation is clearly in the abstract better than regulation either by the amperes alone or by the volts alone, or by the difference between them; and the mechanism is certainly such as can be constructed. Such a lamp ought to run on any circuit. Let it be remembered that on a constant potential circuit a shunt-magnet can do no more than a spring might do. Neither can a main-circuit magnet in a constant current circuit do more than a spring. A lamp in which both coils are properly combined, ought to be capable of working on either kind of circuit. Indeed, there are some existing lamps which will very nearly do so.

Relay Lamps.

It is evident that the brains of the lamp need not necessarily be placed inside the lamp itself; the device of using a sort of *relay*, outside the lamp, to watch the lamp and control its feed, is one that has been frequently suggested (Crompton, Abdank, Gerard, &c.). There is one lamp (Jolin, 2570^{83}), in which a shunt relay, itself too weak to move the feed tilting-plate, does the work by opening and closing one of the circuits of a double, differentially wound main-circuit electromagnet.

Retarding Mechanisms.

It would be very easy to write a whole chapter on fans, air dashpots, glycerine dashpots, and the innumerable devices which have been

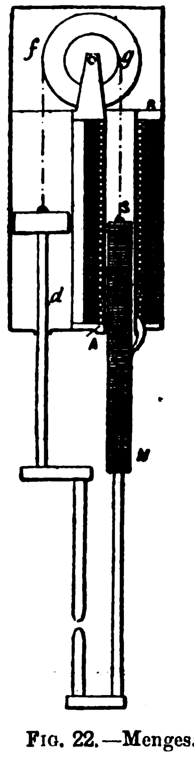

Fig. 22.—Menges.

tried. Two are worthy of mention—namely, Hopkinson's device (153^{81}) of altering the rate of feed by raising or lowering mercury in a vessel in which a fan is continuously rotating, and Brockie's suggestion of a liquid brake-wheel containing internal partitions, communicating by small apertures, so that a liquid could flow but slowly from one chamber to another.

Replacement Mechanisms.

These may be classified as follows:

(*a.*) In rack-train lamps, a ratchet-wheel on first or second member of train.

(*b.*) In clutch lamps with loose clutches, none required.

(*c.*) In forward-feeding clutch lamps, some device for loosening the clutch.

(*d.*) In screw feed lamps, some device for unclamping the screw gearing.

Focussing Mechanisms.

The various ways of giving to the carbons the desired differential rates of approach are best classified by reference to Fig. 24, which gives four methods of producing a motion of the carbons in the ratio of two to one, and four methods of "commercial focussing," in which the carbons are moved toward one another at equal rates.

Change-over Mechanisms.

These may be classified into those which are purely mechanical (Brush, Thomson-Rice, Bürgin, Crompton-Crabb, etc.), and those which are electrical, the current being switched off from one pair of carbons, and switched on to another (Weston, 1163^{82}; Waterhouse, 5185^{81}; Trott and Fenton, 6910^{87}; Noble, 16376^{87}; etc.).

Cut-out Mechanisms.

"Cut-out" mechanisms may also be purely mechanical; but they are more usually electrical, and, in modern forms, enable the lamp to "cut-in" again, on the re-establishment of its proper circuit. Cut-outs which enable a shunt-magnet to strike and feed the arc are described by Lever (8443^{84} and 11501^{84}), and are used in the Thomson-Rice lamp. The latest devices are those of Lauckert (5707^{87}), and Phillips and Harrison (7235^{87}). In many lamps the cut-out circuit is merely a shunt electromagnet stiffly set, which, on the failure of the lamp, receives the whole current, and pulls over a cut-out switch. Gerard (4792^{81}) describes several such devices, as well as a cut-out depending on expansion by heat. In the Pilsen lamp (Fig. 21), the cut-out is in an auxiliary main circuit. Cut-outs depending on the fusion of a wire or of a washer have been proposed by Lontin (2094^{77}), Basilevsky (5026^{84}), and McDill (1887).

The action of change-over and cut-out mechanisms is well illustrated by reference to the Thomson-Rice lamp, of which Fig. 25 illustrates the electrical mechanism, and Fig. 26 the mechanical mechanism of the lamp. The terminals are marked + P and − P. The carbon-rods, C C and C_1, C_1, are held up by their respective clutches, which are identical with those of the Thomson-Houston lamp (Fig. 14) already described. The clutches, when the lamp is not at work, are themselves held up by the spiral springs, X X, which push down the levers, J and J_1, and push up the arms, H L, and H_1 L_1, so gripping the rods. The principal electromagnet, S, with its conical poles, has a pierced armature, *a a*, mounted on the end of a strong lever, M N (Fig. 25), which is pivoted at O, the short tail, O N, being pulled down by a powerful spring, X. This lever, thus held up above the poles of the electromagnet, is connected to point P (Fig. 26) of the clutch-frame, and holds it up. The adjusting nuts of this frame are so set that when P descends, the lower end, F, of the pin, E F, strikes on the base plate and opens the clutch for the left carbon-rod, so striking the arc of this pair of rods. When the pencils of this side are consumed, the rod C C has descended so far that its projecting head, K, strikes the long lever, M M, the other end of which raises the pin, E F, so bringing the other clutch into action. The electric arrangements, Fig. 25, are as follows: The magnet, S, is wound with a few turns of thick wire, and with many turns of fine wire. The cut-out (or cut-in) magnet, M, is wound with coarse wire only. The upper carbon-rod is connected electrically to the frame of the lamp, whilst the lower carbon, insulated from the frame, is joined by a wire (not shown in the figure) to the negative pole. The current entering at + P passes first round the coarse wire on S, most of it going through A and B (which are in contact), and on to − P; but a little of it, after traversing the coarse wire coil, turns back along the fine wire coil and goes by this by-pass route to B and − P. As a result, the armature is strongly attracted, and the lever, M N, descends, causing the carbon-rod to drop. This now opens another route for the current. Starting at + P, some of it will flow through M to the frame, thence through the upper and lower carbons and so to − P. This current will attract the armature, A, and break the contact between A and B, breaking the coarse wire circuit through S, leaving the fine wire path still available. Consequently S loses most of its power, and the spring + pulls up the lever M N, so striking the arc. The shunt-circuit (fine wire) through S is still at work, and continues to operate the feeding, increasing as the resistance of the arc lengthens.

The present attempt to furnish a classification of the various mechanisms, electrical and mechanical, of the arc lamp, is probably extremely imperfect, but it may at least claim to supersede the old and ludicrous division of lamps into "monophotal" and "polyphotal.' In conclusion, it may be pointed out that there exists a curious sort of family likeness between the several members of the three species of lamps most in use. The rack-train lamps, which may be considered as the prevailing continental type, are for the most part, in their design and construction, essentially clockmakers' lamps; they have a horological aspect. The clutch lamps so universal in America have a sort of sewing-machine look, the working parts being only finished where necessary for actual work, all else being left rough or merely painted over. The clutch-wheel lamps favoured by British inventors have, in contrast to these, a look as though they had been designed and constructed by a trained engineer; they are essentially engineers' lamps.

APPENDIX.

Sample of Filling up of Schedule.

SCHEDULE OF ARC LAMP MECHANISM.

Name of Lamp.—Thomson-Houston. Single arc.

Nature of Supply.—Constant current; *amperes* 9 8.

Resistances.—*Main-circuit coil*, 0·09; *shunt*, 279; *cut-out*, 0·85 *ohms*.

A	*Driving power* ...	Gravity on upper carbon-rod.
B	*Striking*	Main-circuit electromagnet attracts lower end of see-saw, lifts clutch.
b	*ditto adjustment*	(1.) Special resistance-coil shunting main-circuit coil. (2.) Spring on tail of clutch.
C	*Feeding*	Shunt electromagnet attracts upper end of see-saw, lowering clutch.
c	*ditto adjustment*	Same as *b*.
D	*Moderating*	Air dashpot on horizontal tail of see-saw.
E	*Replacement*	None required.
F	*Focussing*	None.
f	*ditto adjustment*	None.
G	*Change-over*	None.
H	*Cut-out*	Insulated contact on lower end of see-saw, pulled over by shunt-coil, and puts cut-out resistance as shunt from + to − terminal.

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BOARD OF TRADE ENQUIRY.

Major Marindin, C.B., C.E., on behalf of the Board of Trade, opened an enquiry at the Westminster Town Hall, on Wednesday last, for the purpose of hearing, on the part of a number of electric lighting corporations, their provisional orders to erect and maintain electric lines and works, and to supply electricity within certain areas in the metropolis and elsewhere, and the objections raised thereto by other companies and corporate bodies.

The first case that came on for hearing was that of the London Electric Supply Corporation, Limited, who were represented by Mr. Pember, Q.C., Mr. A. K. Lloyd, and Mr. J. C. Graham, instructed by Messrs. Deacon, Gibson, and Metcalfe. The application of the corporation was opposed by Mr. Moulton, Q C., and Mr. R. S. Wright, instructed by Mr. Sidney Morse, on the part of the Chelsea Electric Light Company and the Electric Power Storage Company.

In opening the case for the London Electric Supply Corporation, Limited, **Mr. Pember** said that the authorised capital of the Corporation was £1,250,000, the subscribed capital was over £800,000 the paid-up capital, £585,000; the sum that the company had already expended on the prosecution of their works was £430,000 odd, and therefore they had on hand of actually paid-up capital over £150,000. He mentioned these figures merely to show that the inspector had to deal with a company which was financially very large, very powerful, and thoroughly substantial. He would presently give a little more in detail the nature of the machinery and buildings that were in course of erection, from which it would be seen that the company had not only got money, but that it was being spent in a wise and farseeing way. The company began operations by buying out the station known as the Grosvenor Gallery—in other words, by buying out what they called Sir Coutts Lindsay and Co., Limited. From that station they supplied—in a manner which would be detailed by the witnesses—something like 33,000 electric lights. They had gained in the course of the business that had been conducted there—a business which had afforded them very great insight into the method of supplying electricity for private, domestic, and public purposes—considerable experience, and he might say at once that it led them to the absolute conclusion that it was not expedient to have generating stations in populous neighbourhoods. Their intended system was the very opposite of that. They proposed, instead of having a generating station in each locality of London for the purposes of supply, to have one large station at Deptford, in Kent. From that station they proposed to have trunk mains running into London along the railway embankments and across the parapets of the bridges, with high-pressure currents; while in London itself it was intended to lay distributing mains along the streets, establishing local stations for converting the current and supplying light to private consumers by means of ordinary wires carried into their houses. There was a very sharp line of demarcation between that system and the one which he believed all those who were competitors to them adopted, and was identical with that which had been carried on at the Grosvenor Gallery station. The area of the provisional order which they asked for was undoubtedly a large one, but if it was compared with the one originally asked for it would be seen that several parishes had been struck out.

Mr. Moulton requested that the names of the parishes now omitted from the original plan (a sketch map of which was handed to the inspector) should be at once read.

Mr. Pember said they were as follows: St. Mary Abbots, Kensington; St. John, Hampstead; St. Mary, Islington; St. Leonard, Shoreditch; St. Luke; St. George-in-the-East; the Whitechapel district; St. Mary, Lambeth; and St. George-the-Martyr, Southwark; thus leaving as their area of supply the parishes of St. Martin-in-the-Fields; St. Margaret and St. John (united), Westminster; St. James, Westminster; St. George, Hanover-square; Chelsea; Paddington; St. Marylebone; St. Pancras; St. James and St. John (united), Clerkenwell; the Strand district; the St. Giles' district; the Holborn district; the City of London and the Liberties thereof; and the extra parochial places of Lincoln's-inn, Gray's-inn, and the Inner and Middle Temple, all in the county of Middlesex; the Greenwich district, in the county of Kent; St. Mary, Rotherhithe; St. Mary, Newington; St. Mary, Bermondsey; the districts of St. Olave, St. Saviour, and Christchurch, in Surrey. That gave the area of the order, which would be clear to everybody. There was one point in connection with it to which he wished to call attention. They did not ask for any exclusive grant of the districts over which their area extended. They did not oppose competitors. They were quite ready to allow the Board of Trade to grant an order to anybody else within the limits of the area over which they sought power. That being so, it seemed to him, and he could not help thinking that Major Marindin would agree with him, that there were two main questions of principle involved in their case. The first one he would formulate in this way: was it advisable to grant a large area to any one company? Secondly, was it advisable to give to more than one company powers over the same area? They, of course, answered "Yes" to both questions. He would at this point suggest that Parliament obviously intended that there should be competition. He remembered very well Mr. Stanhope's Committee of 1882, at which they discussed the question of competition *versus* a regulated monopoly, and he recollected that the theory of a regulated monopoly, such as was the case with gas companies, was rejected, the committee electing to leave the matter open to competition, and it was for that reason that they fixed no maximum price for electricity in 1882. If that was the principle upon which Parliament proceeded, it would be obvious that the Board of Trade should be open, at all events, to consider the question of unlimited competition in an area. If the question were answered in the affirmative by that body, it was clear that the first question would be answered in the affirmative, too, because if it was held advisable to give several companies power over the same area there was no harm in giving a company that worked over it as large an area as it might be able to cover. But he wished to point out that the possession of a large area upon which a company could employ its capital profitably—with the hope, in fact, of getting a large and remunerative business—was a very great encouragement to the application and investment of a larger capital, and surely when the money was well applied and wisely invested it induced cheapness in the article supplied by economical working. It encouraged a company to seek out the very best appliances from time to time, and generally offered an encouragement to enterprise, making it profitable to the public as well as to the company concerned. That was his view of the case. At all events this they were clear about, that there was nothing to prevent the Board of Trade from giving effect to the view in the two Acts of 1882 and 1888. It had a perfectly free hand in the matter, and they hoped the Board of Trade would give effect to it. He thought that if Major Marindin saw the works of the company at Deptford, to which he (the speaker) advised him to pay a visit, he would admit that though they were large they were very compact, and that he would feel, as the speaker did, they were a thoroughly well-devised attempt on the part of a company that hoped to be one of the forces of electric light in London, and to do something analogous for the public to what the Gas Light and Coke Company did when they removed out of London—to the great relief of the community—their works to Beckton. In fact, he hoped that Deptford would become, so to speak, an electrical Beckton. Their works consisted of four double engines and dynamos, two of 10,000 h.p., and two smaller ones of 1,500 h.p. each. The two latter would be ready for use in the course of a month from that day. The first large one would be ready in the month of November, and the second in December. Those engines would be amply sufficient to give a constant supply of 230,000 lights, and it was not too much to say that the plant could be quadrupled very speedily if it were required. He believed he did not overstate the case when he said that the company on their present premises could, if they were called upon to do it, give a daily supply of a million lights. For the carriage of the trunk mains into London, they had a very simple and very wisely designed expedient. Instead of breaking up the streets as they came along, they had made an agreement with the South-Eastern Railway Company, with the Brighton Railway Company, with the London Chatham, and Dover Railway Company, and with the Metropolitan Railway Company for the carriage of the company's mains along their respective lines, and outside the parapets of their bridges, so that there would be no breaking up of the streets in the suburbs as the mains were brought into town. The mains would be brought in at Charing Cross, he believed, South Kensington, and at various other points. But this was a matter which he would prefer to leave to the witnesses. Suffice it to say that the mains would strike the streets of London at convenient places. The high-pressure currents would be converted into low-pressure currents at their stations, being thence distributed, as he had said, by the ordinary supply wires to the different private and other houses desiring to use the light. Let him say a word as to the relative advantages of their system and those of other systems. In the first place, there was the removal of the different generating stations out of town to one place in the suburbs, which was a very great boon to all the parishes to be supplied. There would be no noise of moving machinery on a large scale at several spots, there would be no smoke, no vibration, and no carriage of coal through the streets. As to the first three matters, very little need be said. It was obvious that the absence of the manufactory itself must be a great advantage to everybody, for he believed that it was conceded on all hands that there was a nuisance caused by existing stations in London. There was one, he believed, at Paddington, another at Jermyn-street, and a third at the Grosvenor Gallery, where the nuisance was proved to be very great. In fact, he did not go too far when he said that lawsuits in connection with the nuisance so caused had been avoided only by the fact so far as the company were concerned, that they had assured those who suffered from it that they were doing their very best to persuade the Board of Trade to give them the order and adopt their system. The community had therefore shown a certain amount of forbearance over what he hoped would be only a temporary inconvenience. As to the matter of coal, that stood on a somewhat different footing. He was told that if 200,000 people were supplied with the electric light—and a very moderate estimate indeed would be one light per head, which would make 200,000 lights—he was told that, if the electricity required to take that number of lights to London were manufactured there, 408 tons of coal, or thereabouts, would be required for their production daily. He would ask them to note that that quantity of coal was calculated on the assumption that no condensing engines were of practical use in such populous places as they were dealing with. Now, 400 tons a day would be carted in 200 loads. To that number would have to be added a certain number more for the removal of ashes and the carriage of oil and other things. Let them say that 10 at least would be added. That would mean an addition to the traffic in the streets of the heaviest class of vehicles, not to mention the obstruction caused by the unlading of the carts, and the destruction of the roads, which would not be inconsiderable. They had then to consider the question of coal storage, which would not be practicable to any great extent, and the consequence of that would be that it would leave the undertakers of the enterprise to live from hand to mouth, as it were, with the result that in the event of a heavy snowstorm or fog, or any other condition of things which would prevent the ordinary supply of coal coming with its accustomed regularity, there would be a great part of the parishes supplied with the light left in temporary darkness. Let him now turn to another advantage—the economy of production—which their system involved, and the consequent cheapness of price to the consumer under the spur of competition. First, there was the concentration of the plant and premises for the purposes of production, in itself no mean advantage. Their main station out of

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London would be on cheap land, and would be an agglomeration of several small stations, with a collection of engines, dynamos, and other plant in one building. There would be facilities for the storage of coal, and there would be economy of management in the shape of labour, in the shape of space, and in the shape of plant. The ready substitution of one piece of machinery for another could be readily effected by the mere turning of a switch in case of any accident happening to one piece. Again, and this was a very important point, they got cheapness, facility, and regularity of the coal supply, because they had a large wharf on the banks of the river to which their own steamers could get up. He was told that, setting aside all other advantages, in this respect they would have an advantage in the price of their coal alone by having to pay only something like 12s. 6d. to 15s. a ton, whereas they had now to pay 20s. to 25s. a ton in one of the central parishes of London. Finally, they had plenty of space, and an abundance of water at command. There were other advantages peculiar to their mode of producing electricity, and from the method of distribution, not to mention the small loss of the electricity generated, which would be better explained by more scientific witnesses than himself. Mr. Ferranti, their electrician, would explain the advantages of the continous current over the storage system which depends on the use of accummulators.

At this stage of the proceedings, a specimen of the mains which the company propose to use was handed in. They consist of an inner and outer copper tube, of about 2¼in. in diameter, the current having to pass up the inner and down the outer tube, the outside of which is carefully insulated.

Mr. Pember, continuing, said it would be plain that by the use of these mains the breaking up of the roadways was reduced to a minimum. While on this subject, he wished to add that they were perfectly willing to co-operate with any other company that might be serving the same district as theirs, so as to secure a joint opening of the streets from time to time, and thus prevent the multiplication of the process. Their system of distant transmission had been thoroughly well tested, and 30 miles were found to be a perfectly safe distance for transmitting electrical energy. But, of course, the distance over which their currents would be transmitted was far less than that. He thought it was now necessary to notice the other orders, and the attitude of those who sought them, as well as that of the vestries, to the London Electric Supply Corporation. Having enumerated the various companies who are asking for areas to light, he went on to say that the list of orders asked for he would dismiss by saying that the company only opposed them generally, having nothing to say against them, or to show how much better the company's system was than other people's. The method of other companies did not concern the London Electric Supply Corporation except on one condition, and that condition was in the event of the Board of Trade saying only one company should be allowed in one area. If that were to be the rule guiding the Board of Trade, then the London Electric Supply Corporation would oppose them all equally. They said that their system was the best for the supply of London, and if the system of competition were adopted, and one or more companies were allowed to go over the same area, this company were so thoroughly confident of the conditions and the terms they gave that they did not fear the presence of any number of other companies in the field. He found that in the parish of St. Martin-in-the-Fields the Metropolitan Company asked for a special Act, which he believed was to be brought before them for the purposes of that enquiry as a provisional order. Then the Electric Power Supply Company asked for powers in St. Martin-in-the-Fields, and so did the Westminster Power Corporation. (A voice: "The Westminster Power Corporation have abandoned that.") With regard to St. Margaret's and St. John's, Westminster, any definite action was postponed until after the Board of Trade enquiry. Then cames St. James', Westminster, in which the Metropolitan Electric Supply Company had asked for a special Act for it, as well as for St. Martin-in-the-Fields. The Westminster Electric Supply Company were there also. The vestry there assented subject to certain amendments, which, of course, had to be discussed. In St. George's, Hanover-square, he found that the Metropolitan, Chelsea, and Westminster Companies were all competing with them. In Chelsea they found the Metropolitan and the Chelsea competing with the existing order. The parish there agreed. In St. Marylebone they found the Metropolitan Company against them, and there the vestry withheld its assent. When they came to the Strand they found the Metropolitan, the Electric Power and Storage competing against them. (A voice: "Westminster has withdrawn.") The Strand dissented. In St. Giles they found the Metropolitan against them, the vestry assenting with conditions. In Holborn they again found the Metropolitan, and again the vestry assented with some slight condition. In the City of London they found the Metropolitan once more, and the City dissented. In the Clerkenwell district they had no competitor, and the local authority assented with conditions. In Rotherhithe they had no competitor, and the parish assented with conditions. In Lambeth the Metropolitan cropped up again, and the parish had issued a formal objection. There were two parishes—St. Mary's, Bermondsey, and St. Olave—where there were no competitors, and the authorities assented conditionally, and lastly there were St. Saviour's and Christ Church, where they found the Metropolitan, and where the local authority assented.

Major Marindin: Conditionally or absolutely?

Mr. Pember: Absolutely, I think. He must ask to go a little through the objections raised, and for that purpose he would take a typical parish or two, and by those means the general scope of the objections would be made clear. The first objection he would like to mention was one which he hoped the Board of Trade was not in the least likely to entertain. It was that the 42 years during which the companies were to be allowed to have enjoyment of their order, and which was settled by the legislation of 1888, should be cut down to 21 years, which had been previously settled by the Act of 1882. He thought that Parliament and everybody concerned had come to the conclusion that 21 years was a great deal too short a period, and that the electric lighting enterprise had been greatly crippled by the Act of 1882. The committee appointed by the House of Lords, and presided over by Earl Camperdown, in 1886 had such overwhelming evidence as to that fact that the Act of 1883 was the direct outcome of it, and considering the great retardation in the development of electric lighting, he did not think that Parliament or the Board of Trade would hark back to the 21 years' limit. He could quite understand a local authority desiring to get hold of such property on easy terms. He would select the objections raised by the parish of St. James', Westminster, which were fairly typical ones.

Mr. Moulton asked that the objections should be put in.

Mr. Pember said that he would hand them over to the opposing counsel in the course of the day. The first objection had reference to the power of the company to transfer their undertaking. It was certainly an open question whether undertakers under a provisional order could or could not transfer their undertaking. He saw in the legislation of 1882 and 1888 no express power enabling them to do so. He saw clause 11 of the Act of 1882 pointed to the notion that they were to be allowed to transfer an undertaking providing the Board of Trade consented. It was a matter, at all events, it seemed to him, not for the local but for the supreme authorities to determine—namely, the Board of Trade—and they were abundantly safeguarded against any improper transfer. The next thing that he noticed with regard to the Vestry of St. James', Westminster, was that they asked for the insertion of a clause requiring them to satisfy the Board of Trade as to their financial responsibility. He should have thought that the Board of Trade, until they were satisfied of what was called their responsibility, or their substantial power to carry out what they intended, would not give the company an order at all. The company did not blink any enquiry into their financial position. It was as sound as that of any company could be. Another suggestion made was that the parish asked that the undertakers should provide in some way a deposit of money for the satisfaction of the Board of Trade, presumably as a guarantee that they would carry out the work. He felt to treat that matter as a question of degree. If it were a question of depositing, say, £10,000 or £20,000 in respect of the whole area, to be repaid in the manner which the parish might indicate, he did not know that his company would offer any serious objection to it. But if it were to go much beyond that figure, if it were to be anything like such a sum as had been hinted—about £5,000 for every parish concerned, for example, and there were about a dozen or twenty parishes—that would amount to a serious sum of money, and he did not think it wise to recommend the Board of Trade to recommend such a suggestion. It would be against public policy to lock up such a sum of money, which might be very well expended on the furtherance of the order itself. The next point he noticed was that it was desired to insert a provision prohibiting the placing of any electric line above ground, along or across any street without the express consent of the local authority. He thought that was a point that ought to be determined by no one but the Board of Trade, who would consider it on its merits. The next amendment he cared to notice was that the distributing-boxes which were to be placed in the street should be of a size and pattern to be approved by the local authority. To that his only objection would be that it would be giving the local authority too much power in a matter in which they might not be able to form a judgment. Coming to the question of overhead wires, he said that was a matter with which they must deal with considerable care. The proposal was that words should be inserted to the effect that the order was to confer no powers to place overhead wires. If those were the exact words he would have, he thought, no objection; but he would strenuously object to the words going one bit further. At the present moment they believed, in common with a great many other companies, telegraph and telephone companies, that they had the common law right of owners and occupiers to carry the wires at a sufficient height as to take them from house to house. It was common knowledge that such wires were carried all over London, and they would strenuously object to any words being inserted which would have the effect of controlling or limiting their present legal rights in the matter. The next point was that the undertakers might forthwith and should be bound to lay their mains compulsorily at any time after the expiration of 1½ years after the commencement of the order. That was a question of degree. The next point was in section 15, which dealt with the failure of the undertakers to lay down mains, etc., in which case the order might be revoked, and the words as to the whole or part of the area were substituted for the words as to whole or part of a street.

Mr. Moulton observed that that was a most serious point in the order.

Major Marindin: If you fail to supply any particular street, the order may be revoked as to whole or part of the area in respect of which default shall be made. That is as I understand it.

Mr. Pember said that the next proposal was the substitution of courts of summary jurisdiction in lieu of the arbitrator appointed by the Board of Trade. That had reference to clause 16. He could not help thinking that an arbitrator of the Board of Trade was a far better person than a police magistrate for dealing with any such questions as might arise under the order. Clause 18 provided that, "where any such requisition is made by the local authority, it shall not be binding on the undertakers, unless at the time when such services is effected, or within 14 days thereafter, there be tendered to the undertakers (it required by them) an agreement executed by the local authority for binding them to take for a period of three years at the least a supply of electricity for lighting such public lamps in the street, or part of a street, in respect of which such requisition is made as may be under their management or control, and to pay for the same an annual sum not exceeding 20 per centum per annum upon the cost of providing and laying down the required distributing mains, and any other mains or additions to existing mains which may be

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necessary for the purposes of connecting such distributing mains with the nearest available source of supply." To that was added: "Provided that in streets where the undertakers have distributing mains laid for the purpose of general supply it shall not be necessary for the local authority to guarantee any annual sum except the cost of the electric current actually consumed by them." Now, as he understood it, the requisition which that particular parish—St. James', Westminster—had made upon them was that they should be compelled, if it were required, to lay in those mains and to give the supply in street lamps without that guarantee of 20 per cent., notwithstanding that clause 43 provided the price to be paid by the local authority for the public lamps should be settled between the local authority and the undertakers. It was obvious to everybody, he believed, that the least remunerative part of the business either of an electrical company or a gas company was the supply of the lights to the public streets; and he thought it would be, to say the least of it, very hard if the local authority, in a street or part of a district where there was nobody caring to take the electric light for the purpose of private consumption, were to call upon the promoters to lay mains down that street for the purpose of lighting the lamps without some consideration. It was true that in section 43 it could be settled by agreement between the parties, but it was equally true that unless street lighting were supplemented by private consumption, electricity would not pay at all. As to the insertion by the local authority of testing places and the necessity for keeping instruments for making tests, he did not think that they would object to that. As to clause 36, where it was suggested that where there was ground for apprehension of their supply being interfered with, owing to the defective conditions of the consumers' fittings, there should be a right of appeal to a court of summary jurisdiction. There, again, he thought that any such dispute would be better settled by an ordinary Board of Trade arbitrator. Under clause 38 it was proposed to increase the distance within which street lamps were to be lighted from 50 to 75 yards. That the company readily acceded to. In clause 39 they had a proviso intended to protect them against responsibility from default which did not arise from negligence, for which it was said there was no necessity. But he did not agree with that view. The next amendment of importance had reference to the 56th section, relating to the exemption of generating stations from "The Metropolitan Building Act, 1855." They asked that the rules which governed that Act should not be made applicable to any building of the company three miles from St. Paul's Cathedral, and used by them wholly for the generation of electricity. After alluding to some other minor objections, he said he would ask the inspector to consider the different objections, and if they were not sound, to disregard them. At the same time, if they were sound he ought to report to the Board of Trade to that effect, and the Board would refuse or give to the company their order, either absolutely or conditionally, as the case might be. But he would ask the inspector to consider that the dissent of any of those local authorities, or any objection conditionally on the part of those local authorities, was in the nature of a veto, and it was obvious that if they looked at section 2 of the Act of 1888 no such veto was intended to be given. By the Act of 1882, the local authorities had no right to assent or dissent to an order. The Board of Trade had to give their notice that they were to give an order. The question of their anterior assent or dissent was not mentioned. In 1888 there was a modification of that to the extent that no provisional order should be granted by the Board of Trade, except with the consent of the local authority, unless the Board of Trade, in any case, were of opinion that, having regard to all the circumstances of the case, such consent ought to be dispensed with in such case. That made it perfectly clear to his mind that the Board of Trade had the undoubted right to grant the order, or any other order, against the wishes of the local authority if they thought that the wishes of the local authority, either as a matter of principle or as a matter of detail, were unreasonable.

Mr. Goldney (the City Remembrancer) intimated that the City objected to the terms of both companies which proposed to take the City into their area.

The enquiry was then adjourned for a short time.

After the company reassembled,

Lord Crawford and Balcarres was examined by Mr. R. S. Wright in support of the London Electric Supply Corporation's claims, and in the course of his examination admitted that the experience that he had gained at the Grosvenor Gallery led him to the conclusion that the electric light could be better supplied from a large central station in the suburbs than from many small stations in a populous neighbourhood. It had many advantages to commend it. It obviated the nuisances of noise, smoke, and vibrations from the working of machinery, and many others. A large area could be undoubtedly worked by one company. He gave it as his emphatic belief that the development of electricity as a motive power would completely throw into the shade its development as a lighting medium. He endorsed the remarks of Mr. Pember in his opening statement as to the amount of the company's capital, and the character and extent of the works at Deptford. The distance which electricity could be transmitted for their purposes was to be counted by many miles, and it could be done with absolute safety to the public. Being at Deptford, the company could save greatly on its coal account, while considerable economy in the management could be effected. He did not know that it was an advantage to the undertakers to have one or more competing schemes in the same area at the same time, but it would certainly benefit the public. By the mains that they proposed to lay there would be no yawning chasms in the roadways which were caused by the laying of gas mains, for they would be quite satisfied to lay their tubes about 10in. to 12in. below the surface of the ground. There was no reason why two or more of these mains should not be laid down in close proximity to one another.

Cross-examined by Mr. Moulton, the witness said he saw no objection to two or more companies working in the same area. There were certain objections on scientific grounds as to testing, distributing-boxes, and so on, which he was prepared to leave to the Board of Trade to decide as between them and their competitors. He did not think that every method that the company were adopting was open to any other company to take up. The advantages which they derived from their removal were chiefly in connection with their having chosen a site for their works conveniently situated near the river, which would result in many economies and facilities not otherwise attainable. Their plant would supply 230,000 lights. The statement with regard to the procession of 200 carts a day was taken from their experience at the Grosvenor Gallery. They proposed to distribute in their mains at a pressure of 2,400 volts. Their second transformers were in the customers' houses.

Cross-examined by the City Remembrancer (Mr. S. Prior Goldney), he further deposed that they had got applications for from 70,000 to 100,000 private lights. They included the City in the area because they hoped to do good business. He could not say that they had made any special calculation as to the amount of profit to be made from the City or any other place. It was impossible to put in any allocation of capital to be spent for the City or any other place. When fixing upon the capital, they decided to have a million to begin with. They then said they would have £250,000 extra in order to provide extra power when that power was required. That capital was practically untouched. They had got no debts. If they got this order he thought they would go to the public for more capital. They struck out the places that had been mentioned simply as a matter of convenience.

The **Remembrancer**: Convenience of supply or convenience of cash?

The **Witness** thought that they put aside altogether any convenience of cash. There was no use worrying about that. To questions subsequently put to him, the witness said that St. Margaret's was abandoned from the very first, because they never intended to work there. As to St. Mary Abbots, Kensington, they were offered by the vestry to light three or four turnip fields and the Kensal Green Cemetery, and he declined to go there.

Major Marindin: As a matter of fact, the Kensington Vestry has split their parish up into five or six areas and given those areas to different companies. The part that this company was given was not likely to be very remunerative. That was the reason which Lord Crawford gave.

The **Remembrancer** next asked why Paddington was abandoned.

The **Witness** replied that they were obliged to abandon certain things, and they abandoned what was most unfavourable to themselves. St. John, Hampstead, and St. Mary, Islington, were taken off because they thought their area too large. The same answer was given with regard to the remaining parishes abandoned. He did not say that a million and a quarter of money would be sufficient to absolutely suffice for the area sought. If they were to light the whole of London, it would require five or six millions. He contemplated lighting the whole of the area as it originally stood, but not by this order alone. Next year or the year after they contemplated getting a further order. He did not see why the City should be eliminated from that particular order.

The Court then adjourned.

LEGAL INTELLIGENCE.

IN RE THE MIDLANDS ELECTRIC LIGHT AND POWER COMPANY, LIMITED.

This was a motion on Saturday last, under section 35 of the Companies Act, 1862, to rectify the register of shares of a company by striking out the name of Mr. Arthur Chamberlain, of Birmingham, as holder of 2,074 £10 ordinary shares, on the ground that they had been issued at a discount, and, therefore, under an *ultra vires* contract. The question raised was whether the contract under which the shares were issued really was a contract to issue those shares at a discount, or to issue them in consideration of a debt of the amount of the nominal value of the shares. An agreement was entered into, dated April, 1887, between Mr. Arthur Chamberlain and the company, which provided for the sale of certain concessions to the company. The agreement also provided for advances being made by Mr. Arthur Chamberlain on account of the company, payable on demand by the company to Mr. Chamberlain, with interest at the rate of 15 per cent. per annum from the dates of the advances, with an alternative that Mr. Chamberlain should have the option of taking shares, to be paid for by the advances, without interest, but with the addition of 15 per cent. on the money advanced. The amount advanced to the company by Mr. Chamberlain to the end of 1887 was found to be £18,041. 5s. 11d., and £2,706. 3s. 9d., or 15 per cent., added to that sum brought the amount for which Mr. Chamberlain was to have the option of receiving shares up to the aggregate sum of £20,747. 9s. 8d. A second agreement was made between the parties in April, 1888, which recited that Mr. Chamberlain had elected to accept in satisfaction of £20,740, part of the aggregate sum, 2,070 fully paid-up shares, leaving a balance due to him of £7. 9s. 8d., and provided that, as soon as that agreement should be registered, that number of shares should be issued to him. That agreement was registered, and the shares issued to Mr. Chamberlain, on whose behalf this motion was made to determine whether the transaction was legal. It was clear that a year's interest was not due on the whole of the advances, so that £2,706. 3s. 9d. was more than interest at 15 per cent per annum.

Mr. Birrell appeared for Mr. Arthur Chamberlain.

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Mr. R. J. Parker, for the company, submitted that the whole agreement of April, 1887, was to be taken together, and the sum of £20,747. 9s. 8d. was therefore a debt due partly for advances and partly for purchase-money; and the shares were therefore issued for an equivalent debt, equal to their nominal value.

Mr. Justice North considered this argument more ingenious than sound, for the parties by their agreement had shown that the transactions were distinct, and had themselves severed them. The nominal purchase-money, he said, was more than the advances and interest. The shares were therefore issued at a discount, and it followed that the contract to issue them was void.

COMPANIES' MEETINGS.

EDMUNDSONS, LIMITED.

The statutory meeting of this Company was held on their premises, 19, Great George-street, Westminster, on the 28th March.

Mr. John R. Wigham, J.P., chairman of the Company, occupied the chair.

The **Chairman** congratulated the shareholders on the satisfactory position of the Company. He stated that a larger amount of trade had been done since the acquisition of the business by the Company dating from July last than in the whole of any year during which the trade had been carried on by their predecessors, and that the prospects of the Company, in view of the advances that are being made in electric lighting, are exceedingly encouraging. He also mentioned that the shares had been all taken up within a few days after the issue of the prospectus, and that they are held exclusively by the customers of the Company and by the Directors, many of the former being amongst the largest consumers of electric light in this country.

The outgoing Directors were all re-elected.

CITY NOTES.

West Coast of America Telegraph Company.—The receipts of this Company for March were £5,950.

Direct Spanish Telegraph Company.—The estimated receipts for March were £2,129 against £1,900.

Telephone Company of Austria, Limited.—This Company has declared the usual half-yearly dividend to 31st ult. on their preference shares at the rate of 6 per cent. per annum.

West India and Panama Telegraph Company.—The estimated receipts for the half-month ended March 31 were £3,714, against £3,714. The December receipts, estimated at £5,149, realised £5,229.

Direct Spanish Telegraph Company.—With reference to the taking over of the Submarine Telegraph Company by the Government, the Direct Spanish Telegraph Company, Limited, announce that the acquisition has nothing to do with this Company.

Cuba Submarine Company.—The number of messages passing over the lines of the Cuba Submarine Telegraph Company during March was 5,992, estimated to produce £4,500, against 4,919 messages producing £3,835. The receipts for December, estimated at £3,500, realised £3,508.

Anglo-American Telegraph Company, Limited.—This Company has declared an interim dividend for the quarter ending March 31, 1889, of 12s. 6d. per cent. on the ordinary and 25 per cent. on the preferred stocks, less income tax, payable on the 1st of May to the stockholders registered on the books on April 1, 1889.

Oriental Telephone Company, Limited. — The report of the Directors of this Company, for the year ending December 31 last, states that the revenue account shows a balance at credit of £6,652, which has been transferred to profit and loss. Including the sum of £3.603 brought forward from the previous year, the amount available for disposal is £10,254, which the Directors recommend should be dealt with as follows: To place £2,500 to a reserve fund, to apply £3,000 in final extinction of preliminary expenses, to write off £341. 4s. 8d. for depreciation of stores and balance cost of reconstruction of the Rangoon exchange, and to pay a dividend of 3 per cent., free of income tax, on the paid-up capital of the Company other than the vendors' shares, carrying forward £686.

Companies for the Month.—The following electrical companies have been registered during the past month:

Bath Electric Company, £10 shares	£25,000
Corinthian Electro-Medical Battery Company, Limited, £1 shares	25,000
Devon and Exeter Turkish, Medical, and Swimming Baths Company, £1 shares	7,000
Halifax Mutual Electric Light and Power Company, Limited, £5 shares	20,000
Laing, Wharton, and Down, Construction Syndicate, £100 shares	40,000
Nottingham Electric Light and Power Company, £10 shares	100,000

Eastern Extension, etc., Company, Limited.—The report of this Company for the half-year ended December 31 states that the gross receipts, including Government subsidies, amounted to £238,854, against £232,660. The working and other expenses, including £23,883 for cost of repairs to cables and expenses of ships, absorbed £71,519, against £69,570, and the net profit for the half-year, with £47,903 brought forward, is £166,101. One quarterly interim dividend of 1¼ per cent. was paid for the half-year, and it is proposed to distribute another of like amount, making, with the interim dividends paid for the first half-year, a total dividend of 5 per cent. It is also proposed to pay a bonus of 3s. per share, or 1½ per cent., making a total distribution of 6½ per cent. for 1888. The balance of £66,101 has been carried to the general reserve fund, which, after being credited with the interest on investments received during the half-year, and debited with the cost of the partial renewals of the Java-Australian cables off the Lombok Straits, amounting to £18,987, now stands at £690,455.

Electrical Power Storage Company, Limited.—The report of the Directors of this Company states that the gross profit for the year is £13,273. 15s. 3d., which includes all royalties and receipts, the bulk of this profit being derived from the manufacture of storage batteries and special apparatus in connection therewith. The expenditure for the year, including debenture and other interest, etc., is £11,709. 3s. 8d., and the balance, added to the amount standing to the credit of profit and loss, makes the sum of £8,372. 13s. 6d., out of which the Directors would recommend a dividend were it not that the increasing volume of business demands a larger working capital, and the best method of securing this has been, and is, a subject of anxious consideration by the Directors. During the year under review there was a considerable increase in the Company's business, while, as compared with the corresponding period of the year 1888, the orders received this year up to date have already nearly doubled. To meet this rapid growth of business, it has been necessary to make a considerable outlay on the Millwall Works, and to increase the staff. This additional outlay amounts to £1,827. 3s. 6d. Among the many new electric light installations employing storage batteries may be mentioned the Lyric Theatre, where a 1,000 16-c.p. E.P.S. battery is erected; the London Joint-Stock Bank; the private residences of Sir Henry Meux, Bart., J. Fletcher Moulton, Esq., Q.C., Alfred de Rothschild, Esq., Dr. John Hopkinson, F.R.S., and the Royal Arsenal, Woolwich. The new form of battery, known as the "1888" type, continues to give satisfaction. A number of scientific and technical institutions have adopted accumulators—viz., the Central Guilds of London Institute, Millard Laboratory, Oxford; Cavendish Laboratory, Cambridge; University College of Wales, Cardiff; Heriot-Watt College, Edinburgh; Queen's College, Cork; and the University of Japan, Tokio. A gold medal was awarded the Company at the Brussels Exhibition for their exhibit of storage batteries and accessory apparatus. Central station lighting, which the Directors have regarded as ultimately the main source for the use on a commercial scale of storage batteries, is at last beginning to attract the serious attention of the public, and it is hoped that many of the applications for provisional orders now before the Board of Trade may be granted and confirmed by Parliament during the current year, as, until that result is attained, the full effect of the alteration of the law by the Electric Lighting Amendment Act of 1888 cannot be felt. The only company in the metropolis which possesses the requisite Parliamentary powers is the Chelsea Electricity Supply Company, under 50 Vic., cap. xviii., with which company a contract has been made for the supply of a large accumulator battery for its central station and sub-stations. The Chelsea Company will work its central station on the distribution system of the E.P.S. Company, and will supply light during the present month. Batteries have also been furnished for central stations in various parts of the kingdom. Accumulators for train lighting have been in demand. Extensions have been made to the lighting plant of the London, Brighton, and South Coast and Great Northern Railways, and batteries for this purpose have also been furnished to the Midland, London and North-Western, and Taff Vale Railways, and South-Western Railway of Russia. For ship and yacht lighting, a new type of accumulator has been designed, and has been supplied to the British navy, the Italian and Danish navies, and to yachts, among which may be mentioned the "Mohican," "Wanderer," and "Torfrida." The lighting of 40 omnibuses of the London General Omnibus Company is carried out by means of E. P. S. accumulators. In surgical batteries a new use for accumulators has been found, and a portable type battery has been made from which current is supplied to cauteries, induction-coils, motors and lamps, and to give special facility for recharging in London, Messrs. Coxeter and Sons, the surgical instrument makers, have established a charging station in Grafton-street, W.C. For the propulsion of electric tramcars a large order has been received from the Electric Traction Company for storage batteries for six cars for working on the Barking line. An interesting experiment has also been made by Mr. Sandwell in propelling tram cars by batteries carried on a separate truck or bogie. In electric launches, worked from storage batteries, progress has been made, as E.P.S. batteries are used in the "Maldon" and the "Viscountess Bury," the latter a boat 65ft. long by 10ft. beam. E.P.S. accumulators are also employed by Mr. Radcliffe Ward in his method of propelling vehicles on ordinary roads by electricity. Throughout Europe the advantages of the use of storage batteries are gradually being realised, but several causes have tended to delay their general adoption. This year the Directors hope the amount of royalties will be substantially increased, as the various companies and firms with whom arrangements have been made to manufacture E.P.S. batteries under royalty have completed the erection of their factories. These are to supply the batteries in Germany, Austria, Hungary, France, Russia, Finland, and the Scandinavian countries. The Electrical Accumulator Company of New York is pushing the business vigorously in all directions on the American continent, and a pamphlet published by that company, showing how successful it has been in establishing its patent rights in the United States, will be read by the

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shareholders with much interest. The retiring Directors are Sir Daniel Cooper, Bart., and J. Irving Courtenay, Esq., who, being eligible, offer themselves for re-election. The auditors, Messrs. Deloitte, Dever, and Co., also offer themselves for re-election.

NEW COMPANIES REGISTERED.

Corinthian Electro-Medical Battery Company, Limited.—Registered by C. Doubble, 14, Serjeants'-inn, Temple, E.C., with a capital of £25,000 in £1 shares. Object: to manufacture, buy, sell, let or hire, and deal in machines and apparatus for the automatic delivery of goods, etc. The first subscribers are:

	Shares.
E. L. Lovell, Springfield, Barnes	1
F. T. Rushton, 57, Sackville-road, Hove	1
A. Bellingham, 23, Albert-square, S.W.	1
C. A. Bury, Highfield House, Leeds	1
G. M. Duncan, 19, Gordon-street, W.C.	1
C. Spencer, 47, Durham-road, Manor-park	1
C. J. Downie, Canty Bay, North Berwick	1

The number of Directors shall not be less than two nor more than five. The first are E. L. Lovell and F. T. Rushton. Qualification: the holding of £100 stock. Remuneration as may be determined in general meeting.

Halifax Mutual Electric Light and Power Company, Limited.—Registered by C. Doubble, 14, Serjeants'-inn, Temple, E.C., with a capital of £20,000 in £5 shares. Object: to generally carry on the business of electrical engineers, manufacturers, contractors, and electric lighting, and to acquire concessions from or with governments, municipal or other authorities, for the supply and production of same. The first subscribers are:

	Shares.
F. H. Bowman, West Mount, Halifax	1
J. Asquith, Old Market, Halifax	1
J. Haley, Cleckheaton	1
M. Brown, Hipperholme	1
A. Fletcher, 71, Northgate, Halifax	1
G. A. Blackburn, 18, Northgate, Halifax	1
R. Needham, 9 and 11, Crown-street, Halifax	1

The number of Directors shall not be less than three nor more than seven. The first three subscribers to the memorandum of association are the first Directors. Remuneration to be determined in general meeting.

Planet Electrical Engineering Company, Limited.—Registered by F. T. Webster, 7, Great St. Helens, E.C., with a capital of £20,000 in £5 shares. Object: to carry on the business of an electric light company in all its branches. The first subscribers are:

	Shares.
R. C. Batley, Seaborough Court, Crewkerne	1
J. H. Newman, 2, Great George-street, S.W.	1
H. E. Moojen, 18, Broadway, Streatham	1
F. T. Webster, 7, Great St. Helens, E.C.	1
F. Iago, 2, Victoria-mansions, S.W.	1
J. Stuck, 2, Victoria-mansions, S.W.	1
A. L. Shepherd, 2, Victoria-mansions, S.W.	1

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	17¾
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply	5	4½
......	...	Swan United	3½	2½
12 July	12/0	Telegraph Construction	12	42
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15¾

The Manufacture of Aluminium.—For the production of aluminium in France, the Societe Electro-Metallurgique has just been formed with a view to erecting extensive works at Forges (department of Tsere). Heroult's process will be adopted, which is fusing the rebellious metallic alloys by means of a metallic current, and separating the metal by electrolysis. Dynamos, each of 7,000 amperes and 70 volts, generate the current, and two vertical turbines of 300 h.p. yield the motive power. In addition to aluminium-bronze, the plant will produce all the alloys of aluminium, with the exception of such as become volatilised at the same temperature as aluminium. It is estimated that a daily production of aluminium alone of 300 kilos will be attained.

PROVISIONAL PATENTS, 1889.

March 25.

5093. **Improvements in electric batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

5095. **Improvements in the form and manufacture of the frames, plates, and cells of storage or secondary batteries.** Thomas Joseph Haslam, junr., of the firm of Wm. R. Box and Co., 105, Middle Abbey-street, Dublin. (Complete specification.)

5104. **Improvements in apparatus for communicating, by means of an electric current, with railway trains when in motion.** Albert Edward Lewis, 70, Wellington-street.

5116. **Improved electrical storage battery or accumulator.** Thomas Pease, 3, Kimberley-street, Princes Park, Liverpool.

5127. **Electric razor.** Ellis J. Davis, 65-66, Chancery-lane, London.

5131. **Improvements in transformers for alternating currents.** Alphonse Isidore Gravier, 6, Bream's-buildings, London.

March 26.

5140. **Improvements in the laying of underground conductors for the conveyance of electricity.** Sidney William Baynes, 4, Hallfield-street, Manningham, Bradford, Yorkshire.

5142. **Improvements in systems of electrical distribution.** Stanley Charles Cuthbert Currie, 6, Livery-street, Birmingham. (Complete specification.)

5152. **Improvements in electrical, gas, or other lamp globe or shade holder.** Elijah Atkins, 12, Cherry-street, Birmingham.

5176. **Improvements in or connected with electrical installations.** Elmer Ambrose Sperry, 1, Quality-court, Chancery-lane. (Complete specification.)

5209. **Improvements in electrical alternate current motors.** Martin Hamilton Kilgour, 226, High Holborn, London.

March 27.

5241. **Improvements in magnets, magneto-generators, and telephones.** Philip Middleton Justice, 55 and 56, Chancery-lane, Middlesex. (Elias M. Greene, United States.) (Complete specification.)

5251. **Improvements in generating and storing electric energy.** Rankin Kennedy, 46, Gibson-street, Hillhead, Glasgow.

5282. **An electric time indicator, with or without calendar.** Alfred Horace Gladwin, 77, Chancery-lane, London.

5293. **Improvements relating to apparatus for the distribution and conversion of electric currents.** Thomas Hammill Hicks, 45, Southampton buildings, London. (Complete specification.)

March 28.

5322. **Apparatus for obtaining readings from indicators placed at a distance by the agency of electric currents.** Thomas John Murday, 20, High Holborn, London. (Complete specification.)

5348. **Measuring and regulating electrical frequency and currency.** William Edward Ayrton, 2, Upper Phillimore-gardens, and John Perry, 10, Penywern-road, both in London.

March 29.

5377. **Improvements in electrical testing instruments.** Frederick King and William Phillips Mendham, Western Electrical Works, Narrow Wine-street, Bristol.

5391. **Improvements in the method of and appliances for insulating electric wires.** Hermann Aron, 6, Lord-street, Liverpool.

5407. **Improvements in fuses and cut-outs for electric circuits.** Arthur Cecil Cockburn and Henry William Handcock, 32, Gaisford-street, Kentish Town, London.

5423. **Improvements in conduits or supports for electric conductors.** Frank King, 47, Lincoln's-inn-fields, London.

March 30.

5509. **Improvements in electric arc lamps.** Herbert Ernest Fenner, 115, Cannon-street, London.

SPECIFICATIONS PUBLISHED.

1887.

4225*. **Electricity meters.** Hookham. (Amended specification.) 1s. 1d.

1888.

3672. **Electric circuits.** Edmunds. 8d.
5191. **Storage batteries.** Edmunds. 6d.
5704. **Switchboards, &c.** Raworth. 8d.

1889.

362. **Working metals by electricity.** Lake (Thomson.) 8d.
1401. **Generating electricity.** Dyer and others. 6d.
1677. **Electric switch.** Whittingham. 8d.
1892. **Electric motors, &c.** Boult (Serrell and another.) 8d.
2066. **Secondary batteries.** Paget. 6d.
2276. **Primary batteries.** Guitton (Sappey.) 11d.

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NOTES.

Telephones at Milan.—A new central exchange will be shortly installed at Milan, in the Galerie Victor-Emmanuel. Lines will be run for 3,000 subscribers.

Naples.—A proposition has been made to the Municipality of this town for the establishment of an electric tramway consisting of five lines, of a total length of 14·7 kilometres.

Electric Automatic Box Company.—The company of this name has, it is reputed, amalgamated with the Automatic Trading Company, the latter requiring "an increase of capital."

Telephone to France.—M. Coulon, Director of Posts and Telegraphs (says the Paris correspondent of the *Times*), has directed experiments to be made, with a view to telephonic communication between Paris and London.

Elieson Electric Company.—Those of our readers who are interested should not forget the sale of this company s plant at Plashet Hall Works, Romford-road, Stratford, E., on Wednesday next at 12 (for one) o'clock.

Rome. — The Co-operative Telephone Company of Rome inaugurated the installation of electric light in the whole of its central exchanges and offices on the 4th of last month, in the presence of a large number of authorities.

Rotherhithe.—The clerk reported the receipt of a letter from the London Electric Supply Corporation, stating that they did not intend to proceed with the provisional order this session for supplying electric light in the parish.

Paris.—The electric light company for the supply of the district of Clichy, Paris, though yet in formation, has had a concession granted by the Municipal Council, and is negotiating for the purchase of a site for its central station in the Rue des Dames.

Arc Lights in Shaftesbury Avenue.—The large new premises adjoining the Café Monico, taken by a large clothing firm, are fitted with 35 Pilsen arc lights, and are to be run from the station in Holborn from a Waterhouse constant current dynamo.

Royal Meteorological Society.—At the next meeting of this society, to be held at 25, Great George-street, on Wednesday, the 17th inst., at 7 p.m., a paper will be read "On the Deaths caused by Lightning in England and Wales from 1852 to 1880."

Arc Station in London.—We understand that the central station for 200 Waterhouse arc lights in London we mentioned some time ago is progressing satisfactorily, and the engines are now being fixed. It is intended also to distribute power from this station.

France.—On the 13th ult. the President of the French Republic paid a visit to the Edison central station in the Palais Royal, where he was received by M. Am. Vernes, the chief engineer of the company. We are informed that M. Carnot expressed the liveliest satisfaction with the installation.

Distribution of Power in France.—A central station for the distribution of power by electricity has been installed at 18, rue Beaubourg, Paris, by MM. Tschierer and Fuchs, manufactures at Puteaux. A Corliss horizontal engine of 110 h.p., and two Gramme dynamos of 370 amperes and 110 volts are employed.

A Uniform for the Indian Civil Service.—The Government of India has fixed upon a distinguishing uniform for members of the Civil Service—such as the Survey, Postal, Telegraph, and other departments—when attached for service with troops in the field.

The Bell Telephone Patent.—In the Chancery Division of the High Court of Justice, on Monday, before Mr. Justice North, the action of the United Telephone Company, Limited, *v.* Siemens Brothers was disposed of, the parties having come to terms. The action was brought for an injunction to restrain the defendants from infringing the well-known Bell telephone patent.

China.—The Emperor of China having decided to introduce the electric light in his palaces, an engineer from Messrs. Siemens and Halske, of Berlin, recently arrived at Pekin with the necessary material. Before, however, this gentleman will be allowed to proceed with the work of installation, he will be required to demonstrate that the light is not obtained by supernatural means.

Overhead Wires.—In the House of Commons on Monday, Mr. Ritchie, in answer to Sir G. Campbell, said he had communicated with the President of the Board of Trade, who was considering the possibility of making regulations on this matter ; but no power could be given to local authorities to deal with it without legislation, and the Government did not at present propose to introduce a Bill on the subject.

Electric Motor Work.—Mr. Nell, writing from 16, Mark-lane, E.C., informs us that the Sprague Electric Railway and Motor Company, of New York, of which he has been acting as representative, have disposed of their patent rights. Mr. Nell, having large connections for this class of work, is now open to form an alliance or to take up the general agency of a responsible firm with a view to pushing electric motor work.

Electric Lighting of the British Museum.—In the House of Commons, on Tuesday, in reply to Mr. H. Gardner, Mr. Jackson said that it had been decided to extend the electric light to the British Museum, and to make the experiment of evening opening. Sir G. Campbell asked whether the promise had not been made that the first experiment in this direction should be at the Natural History Museum. Mr. Jackson said that it had not.

Electricity at Ipswich.—Messrs. Laurence, Paris, and Scott have recently been called in to light the library at Norwich. The same firm contributed some interesting adjuncts to the exhibition which was held last week at Ipswich. These included two electric motors, one of half horse-power, and another of four times that force, which was used to drive a lithographic press shown in working by Mr. Norman Adlard, of the Butter Market, Ipswich.

The Series Tramway.—We have received from the Series Electrical Traction Syndicate, Limited, a neat and well-printed pamphlet containing the collected "Opinions of the Press" upon their new undertaking at Northfleet. In this pamphlet, the article, with illustrations, describing the line from this journal is given at length. The article in another column is to be taken as impartial criticism to elicit more definitely the advantages or otherwise of this system.

Heavy Steel Casting for Deptford Engines.—A 75-ton ingot was successfully cast at the Parkhead Forge, says a Dundee paper on Saturday. It is the first of a set of

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crankshafts for the London Electric Supply Corporation, Limited, and is 20ft long. The shaft into which it is to be forged is 26ft. long by 36in. diameter, being for the largest electric lighting machine in the world. The shaft, with a 12in. diameter hole through centre, will itself weigh 23 tons when completed.

Electric Parcel Cart.—At the end of our article on the electric omnibus, we mentioned that the Ward Electric Car Company were intending to build an electric parcel cart for an enterprising London tradesman (not Whiteley), which is to be run at a speed of 12 miles an hour, for delivery of goods in the suburbs. The cart is now in a fair way of completion. It is rather high in appearance, with three wheels—something like a tricycle—the two wheels being the driving wheels and the front one the steering wheel. The cart will be running on the roads in three weeks or so.

Davey-Paxman Engines.—The last of six handsome engines supplied by the firm of Davey, Paxman, and Co., of Colchester, will arrive this week at the Paris Exhibition, where they will be employed in supplying the electric light to the great world's fair. These engines, which are all fitted with Paxman's automatic expansion gear, and with very sensitive governors, range from 40 to 100 h.p., and are chiefly of the Girder type. In addition to these, six Colchester engines from the same firm will be at work lighting the Boulevards, and six more have been supplied to a French syndicate.

Church Struck by Lightning.—A terrific thunderstorm broke over Dartmoor on Saturday afternoon. Among other damage reported is the partial destruction of Walkhampton Church. The north-east pinnacle was struck by electricity and cast down, crashing through the roof upon the organ, at which the vicar's daughter a few minutes before had been seated. The sextoness also had a narrow escape. The destruction is great, but would have been more extensive had not the electricity travelled down the tower by the rainwater-pipe, which was twisted and melted into fantastic shapes, but it saved the tower.

Lighting in Ireland.—Ballymena is getting well abreast of the times in the adoption of electric light, several mills and workshops having been fitted up, Mr. C. C. MacCarthy, Dundalk, having in all cases carried out the installations. Mr. J. Gault has 15 lamps in his meal-mill, and a large number in his sawmill and coal stores; Messrs. Kave Bros'. foundry is lighted by 30 lamps, whilst over 400 are installed in the factory and bleach works of Messrs. J. H. and G. Bellis, Messrs. Morton and Co.'s flour-mill, Messrs. Raphael and Wolseley's handkerchief factory. Several private residences are also lighted.

Amateur Dynamo Making.—We have received from Mr. Alfred Crofts, of Dover, the second edition of his book "How to Make a Dynamo; a Practical Treatise for Amateurs" (Crosby Lockwood and Son). This is a very useful little book for mechanics or amateurs wishing to make their own dynamos, giving practical instructions and working drawings for the construction of a Gramme dynamo of 360 watts (45 volts and 8 amperes). The book has been enlarged to 100 pages, the price being now 2s. The castings for the various parts of the dynamo described can be obtained of the author at 7, Clarendon-street, Dover.

The Electric Exhibition at Birmingham.—On the application of Mr. T. C. Sharp, the Board of Trade have certified under the provisions of the Patents, Designs, and Trade Marks Act, 1883, that the Electric and Industrial Exhibition, to be opened at Bingley Hall in August, is to be regarded as an International Exhibition. The arrangements are progressing satisfactorily. The exhibition, which will remain open three months, will illustrate the application of machinery to most branches of trade, and will also include electrical novelties of exceptional interest. The applications for space are coming in fast, and there is promise of a most successful show.

Improved Telephone Transmitter.—Mr. S. B. Wilkins, the Edinburgh firemaster, has invented a new transmitter which promises to be a useful adjunct to the telephone. It is a bell-mouthed funnel of metal with an outer metal casing which carries the fixings for holding it in position on the telephone, so that the transmitter itself presents a free vibrating surface. It fixes readily to the ordinary mouthpiece of the telephone, and repeated tests have shown that it conveys spoken sounds with much greater distinctness than the ordinary mouthpiece. There are several transmitters on the same principle already in use, but it is claimed by Mr. Wilkins that his invention has a decided advantage in usefulness and cheapness.

Journal of the Institution.—We have received a copy of the last number of the *Journal* of the Institution of Electrical Engineers, containing the remainder of the discussion on Prof. Jamieson's paper on Insulation Resistance, Mr. Kennelly's paper on Imperfect Earths (with diagrams), and the paper by Prof. Forbes, Electric Lighting Stations in Europe. This latter is fully illustrated with plans and diagrams of the Rome and Milan districts, details of the switchboards and the Zipernowski dynamos, and also reproductions of the photographs shown at the meeting of the interior of the engine and dynamo-rooms at the various continental stations. The diagrams showing curves of comparative cost of maintenance are also given at the end of the paper.

Electro-Physiology.—Four prizes of 500f. each are offered by the Société Royale des Sciences Mèdicales et Naturelles de Bruxelles for the best four answers to the following questions: (1) Find the value, in electrical units, of the normal currents which exist in living tissues, such as the nerves, the muscles, and the glands. (2) Find what is the conductibility of the organic liquids (lymph, plasma, serum) of currents of low E.M.F., and, if possible, investigate the conductibility of the tissues. (3) Proceed with the investigations already made of electric endosmosis, and describe the possible applications of the theory of electric endosmosis to the phenomena of absorption and secretion of living organisms. (4) Find if the molecular structure of the protoplasm presents a variable complexity corresponding to the complexity of the functions. The answers are to be sent in by January 1, 1890, to the secretary of the above-mentioned society.

Utilising the Water Power of Canals.—In long stretches of canals there is little fall, but in short stretches there is often considerable water power available. An appropriation has recently been asked in New York for a million dollars to repair the canals of the States, which has been thought waste of money, and a writer in *Electric Power* suggests that a single-track railroad on one or both sides of the canal might be arranged, the power being obtained from water-power stations situated at the locks, a fall of 10ft. or 15ft. being easily obtainable, supplemented on long stretches by steam power. The suggestion seems to be of an ordinary railroad following to some extent the route of

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canal and travelling at all speeds, and we might here suggest that if in any case there were available water power, an overhead telpher engine to draw ordinary canal boats might prove useful for slow traffic. The suggestion is commented upon in *Electric Power* as worthy of consideration, and the editor remarks "Niagara and the Erie Canal would be a strong team."

Beaumont's Variable Gearing.—In this journal for September, 1886, and again on June 29, 1888, we described and illustrated a variable gearing suitable for electric tramcars, the invention of Mr. W. Worby Beaumont, M.I.C.E. Mr. Beaumont has shown us a model of this gearing, which seems admirably adapted to the purpose for which it was designed. A wheel, with interior teeth, is revolved in a positive direction by a small toothed wheel geared to the motor shaft. A loose conical sleeve is arranged as a friction contact on the same shaft, and on screwing this into position by a handscrew the corresponding toothed wheel, otherwise itself stationaary, is revolved by means of a second friction wheel on a countershaft in the opposite direction to that of the driving-wheel. This, of course, alters the actual speed of rotation of the car-axle, and allows it to be driven at a slower speed. The model shown exhibits this action to be simple and practical, and we should imagine it will prove exceedingly useful in solving the problems of electric traction.

Electric Light for Flour Mills.—The extensive system of electric lighting recently established in the steam flour-mills of Messrs. Edward Marriage and Son, Colchester, was yesterday week formally inaugurated in the presence of the Mayor (Mr. E. J. Sanders) and other gentlemen interested in the development of various industries in the borough. The party assembled in the engine-room, where the "Crompton dynamo" has been fitted by Messrs. Christy, Son, and Norris, of Chelmsford, and the Mayoress having turned on the current, proceeded to inspect the mill. The mill is lighted by 120 16-c.p. incandescent lamps within, and outside is brilliant with the light afforded by four powerful lamps. Light refreshments were then partaken of, after which the Mayor and others congratulated Messrs. Marriage and Son on having kept pace in the march of improvement by fitting up their mill with such perfect machinery as they have done, and by employing the electric light. Messrs. Christy's firm appears to be making rapid headway in electrical work and make a speciality of lighting flour-mills. They have already fitted up 20 flour-mills with fittings, etc., for the light, and have orders for others in hand. We are glad to see such progress being made in this important field.

A Telephone Syndicate.—The *Northern Daily Telegraph* announces on authority that, after protracted negotiations, the directors of the three leading telephone companies in England have agreed, subject to the sanction of their respective shareholders, to amalgamate, and that it is their intention forthwith to connect, by a system of improved trunk lines, all the large towns of England and Scotland with each other. The total value of the three properties is close upon three millions sterling, and the area covered is London and all Great Britain up to Inverness, except South Wales and the West of England. It also includes the North of Ireland. In other words, the districts covered are those licensed by the Postmaster-General to the Metropolitan or United Company, the National Company, and the Lancashire and Cheshire Company. At present these companies have a gross revenue of £400,000 per annum. It will thus be seen what a vast corporation is coming into existence through the fusion of these important companies. The development of the system for the connection of all the great towns with trunk lines will be very costly, and alterations will have to be made in the annual rate now charged upon the existing lines. "The details of the telephone amalgamation," says the *Financial News*, "are not yet agreed, but we understand that the settlement will be based on recent market values, United Company shares being reckoned at £15, Nationals at £6, and Cheshires at £1. 11s. 6d."

An Engine - Dynamo - Accumulator Car. — A courageous attempt to take the bull by the horns and obviate all difficulties (rather, perhaps, we might say embrace them all) is made by the Patton Motor Company, of Chicago. This company equip street tramcars, and, not content with the ordinary methods of arrangement, propose to work their cars with everything aboard. That is to say, it is a storage battery system with the charging plant on the car. A small gas-engine will be set in front of the car connected to one or two horse-power dynamos. Under the seats on either side are the storage batteries, to be kept constantly charged by the dynamo and gas-engine. The motor will be underneath the car. The following are the advantages claimed. In the first place, the gas-engine and dynamo can be operated at a very slight expense, and the power can be obtained for much less than horses' cost. By having the batteries constantly recharged there is no need of two sets, which is the prevalent custom with other systems. Neither will they be so large and consequently so expensive as the other kinds. Their aggregate weight will be but about 500lb., it is claimed—scarcely a third of the other batteries. We hope they will get good-natured gas-engines, and have the movable connection to the gas mains perfectly airtight. Compressed gas of the nature familiar to politicians might be useful. We offer this as a kindly suggestion. It is stated that the cars will be running in a month or two. When this comes off, like John Gilpin, "may we be there to see."

Board of Trade Report on the Series Tramway. The Board of Trade have examined and reported upon the series tramway at Northfleet, and is very favourable to the undertaking. Mention is made of the mechanical arrangements generally being well carried out. Steps only must be taken to reduce the jolting at the junctions. Reference is made to the electric brake, no injurious effect to the brushes, it is stated, being caused thereby. The mechanical break must be adopted on any larger system, or for steeper gradients, to all wheels. For safety from unauthorised interference, it is recommended that the switch levers at the ends of the cars should be made movable, so that one set only is used, and these to be carried by the driver from one end to the other on reversing the journey, and removed on stopping. Upon the Board being assured of these conditions being complied with, they will consent to the running for public conveyance of passengers. Captain Cardew, R.E., in his report upon the electrical part of the plant, considers the arrangement a safe and suitable one for the purpose. He considers there is no possibility of inadvertently receiving a shock from the charged conductor, and that it would be very difficult to receive a shock even wilfully. The power is collected and applied in a simple and efficient manner, and he sees no

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reason to apprehend any serious breakdowns or failures with a proper supervision of the generator and motor. He suggests continued attention to the regulation of the dynamo for constancy of current.

The Submarine Telegraph Company and the Government.—The following letter from "A Shareholder" appeared in the *Financial News* of April 8: "Sir,—It is only right that the fate of the Submarine Telegraph Company should be known, in order that others who have invested their money in similar undertakings should be warned. The right of a submarine telegraph company to land cables on the shores of these islands is contingent on the license of the Government to use the foreshore for that purpose. In the present instance, the Government, having resolved to undertake the business of the Submarine Telegraph Company themselves, have in the first place revoked the license to use the foreshore. Having thus rendered the cables useless to the company, the Government next proceed to purchase the cables at a price which it is not too strong to call confiscatory. The sum offered to the company, and which they are forced to accept, is less than a tenth of their original cost, and less than the amount of their net earnings during the last six months. This bankrupt dividend, for it is barely 1s. 4d. in the £, is a grievous loss to the shareholders. It may be said that the company should have provided against such an Act, but in the first place, it could never be anticipated that a Conservative Government would confiscate private proverty; and, secondly, the company have been lulled into security by the written promise of Lord John Manners, when Postmaster-General, to continue their license until 1898. This promise is now repudiated on the ground that it was conditional on the agreement of the French Government; but as the latter refused their consent at the instigation of the English Government, it is hardly a condition which can be taken advantage of by those who prevented its performance."

Lighting and Ventilation at Parliament.—In the House of Commons on the 8th inst., on the vote of £42,379 for the Houses of Parliament, the question of ventilation and lighting came up. Mr. Plunket said that since last session the electric light had been fixed in certain parts of the building, and during the Easter recess it would be carried into the lobby outside and into some other portions of the House. But the committee, he thought, would hardly approve of the Office of Works undertaking a very large extension in the present state of science with regard to the electric light. Sir W. Foster was of opinion that it was high time the House had the advantage of the best form of lighting that was already invented. An improved gas-burner consumed as much oxygen as five men required to breathe, and, therefore, gas ought to be superseded by the electric light, which did not consume oxygen. The atmosphere of the House had been so bad on one occasion that they were compelled to suspend the sitting. Of all places in the world, this House ought to have the atmosphere that was compatible with intellectual vigour. The air of the House was generally five or six degrees too high, and when they went into the lobbies they found the atmosphere still worse. Mr. Bradlaugh complained of the lighting of the dining-room used by members and their friends. Sir G. Campbell also complained of the temperature, and asked for some explanation of the fact that though the electric light had been introduced into the building, the gas bill had nevertheless increased. Mr. Conybeare advocated the more general adoption of the electric light in the precincts of the House. Mr. Plunket said, with regard to the electric lighting, the reason why it had not been carried out more completely was that just for the next few months it was not quite clear whether they would be able to light the whole of both Houses of Parliament more cheaply by making the electric light for themselves, or by obtaining it from some of the great supplying companies. The increased charge for gas, which an hon. member had spoken of, was caused by the autumn session entailing a larger consumption, in addition to which a greater number of rooms were lighted with gas.

Chelsea Central Station.—The work at the Chelsea central electric light station is being pushed forward rapidly to completion, and an unofficial start was made last night, light being supplied, by means of a temporary Brush engine used to charge the accumulators, to a shareholder's house in Sloane-street. We are precluded from giving any but general particulars of this interesting station for the present, as it is yet in course of construction; but a few details which we were able to gather on a recent visit to the station will put our readers in possession of the plan of the system. The Chelsea station is arranged on the system of distribution by accumulators, in sub-stations. The central generating station is situated in Draycott-place, Sloane-square. The first of the sub-stations, at Clabon-mews, Cadogan-square, is now practically finished, and regular distribution may be expected very shortly. The central station is fitted with Babcock and Wilcox boilers (two of which are now fitted) and Willans engines of 75 h.p. nominal, one of which is now fixed. These are to be coupled direct to Victoria dynamos. The latter are separately excited by a Brush plant with Raworth friction gear, and are arranged to supply current through underground mains (laid by Callender and Co.) to the sub-stations with a charging current of 75 amperes at a little over 500 volts. The sub-stations are very ingeniously arranged with automatic switches for charge, discharge, and regulation of pressure, the arrangements being carried out under the direction of Mr. King for the E.P.S. Co., who supply the accumulators and connections. Rocking switches are arranged, for charge in series and discharge in parallel of the batteries in two sets of four in parallel of 53 cells. The rocking switches are worked by a relay by means of the action of a small gasometer collecting gas from a single plate of the master cells. The raising of the gasometer shunts the main current and closes circuit of second rocking switch, when all goes on as before. The regulating apparatus is very ingenious, and secures a constant pressure in the mains, and equal discharge of current from the two sets of batteries. The apparatus seems at first a little complicated for general working, but no difficulty seems to be feared in actual working, and we shall be greatly interested in seeing the result in action of this courageous attempt to use sub-stations of storage batteries in distribution of electric light. As we go to press the secretary sends us a telegram as follows: "Chelsea Electricity Supply Company supplies current in Chelsea from to-night continuously."

Telegraph Charges to France.—Mr. Henniker Heaton, in a letter to the *Times* this week, points out that the proposed reduction of telegraph charges to France under Government control is insignificant. While the internal rate is halfpenny per word in England, we have been suffering from a rate of 2½d. per word to France, and are now threatened with a ten years' agreement at a reduction of

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only halfpenny per word. The *Times* of the 6th inst. has a leader upon this subject, pointing out that the whole matter lies in a very small compass. A telegram from one end of the United Kingdom to the other costs a halfpenny a word. A telegram from one end of France to the other costs rather less—that is, it costs five centimes a word. But a telegram from Dover to Calais, or from any place in the United Kingdom to any place in France, is for the next 10 years to cost just four times as much—twopence a word in England, and 20 centimes in France. What is the cause and what the justification of this difference? This action (it goes on to remark) is as illogical as it is impolitic. The British Post Office makes no charge for submarine telegrams to Ireland, to the Channel Islands, or to any other outlying portions of the United Kingdom connected with the mainland by submarine cable. The charge for telegrams between France and Algeria is the sum of the internal charges in the two countries, no extra rate being levied for the cost of submarine transmission. The postal rate between England and France is the sum of the internal rates charged in each of the two countries, no extra charge being levied for conveyance across the Channel. Why should a departure be made in the case of telegraphic communication from this perfectly rational and intelligible principle. On April 8 Mr. Henniker Heaton recurs to the subject. The estimate, he points out, is "for the salaries and working expenses of the Post Office telegraph service in consequence of the new arrangements for working the submarine telegraph cables between England, Belgium, France, Germany, and Holland, £49,900." Mr. Henniker Heaton states that he was told the money was required immediately, or dreadful consequences would ensue, and five days afterwards he was supplied with a copy of the new arrangements with France, and two days afterwards with copies of the new arrangements with Germany, Holland, and Belgium. Then he learnt for the first time that Mr. Raikes, without consultation, had bound England down for ten years to submit to exorbitant telegraph charges. Mr. Heaton concludes by stating that the Chambers of Commerce in this country intend to take action in supporting the Paris Chamber in its protest against this state of affairs.

The Electric Light for Weybridge.—An adjourned public meeting was held at the National Schoolroom on Friday evening, to receive the report of the committee appointed to consider the best means of public lighting to be adopted for Weybridge. Dr. Sealy (chairman of the committee) read the committee's report, which stated that some step was imperatively required to place Weybridge more on a par with other residential parishes. Mr. T. Hawkins, who had acted as secretary to the committee, had gone carefully over the roads, and calculated that 85 lamps would be sufficient for the purpose, which estimate was afterwards adopted by the committee. The committee then considered the three different methods—gas, oil, and electric light. The Walton Gas Company offered to erect lamps for £2 per lamp complete, and supply the same with gas from October 1 to March 31, from sunset to midnight, at £1. 19s. 10d. per lamp. Eighty-five oil lamps, the committee found, of 35 c.p., with posts, etc., complete, could be erected, kept lighted and extinguished, for 26 weeks from dusk to midnight, all responsibility of breakage, etc., being borne by the contractor, for £295. A considerable desire existed in the neighbourhood for electric lighting, and this was no doubt called forth by the strong feeling of antipathy which existed towards the local gas company, as well as the desire of many to furnish their houses with the least injurious illuminant known. An offer had been received to erect the necessary plant and supply the lamps at 45s. per lamp, the light thus applied to be available during the summer as well as winter months, from dusk to 1.30 a.m. The committee unanimously recommended the last-mentioned method, being most in accord with the age in which they lived, as well as from every point of view most economical and desirable. In conclusion, they considered that the rate to be made should be 2d. in the £, which would produce £240 on the present rateable value. In reply to remarks by Mr. Thomas and Mr. Wardle, Dr. Sealy said there was no doubt, if the committee had been in a position to make a definite bargain, they could have got much more favourable terms. The Electric Lighting Company whose estimate they had received—Messrs. Laing, Wharton, and Down—was at present engaged in lighting Reading. He should suggest, however, that they should form a consumers' company amongst themselves. He thought the people of that neighbourhood had already suffered considerably at the hands of outside providers. Mr. Thomas said that Weybridge presented the special difficulty that they had the heath and common, two centres of population widely apart, and he thought the present was an unfortunate time to have selected for the adoption of lighting. He believed that the place of similar size had yet to be found where the light had been a success, and he thought the question should be postponed. Major Travers said he understood the company contemplated electric boats up and down the river, and that Weybridge would be the station for supplying the electricity, and that this enabled the offer to be reasonable. Dr. Sealy said it was true that the company thought of having stations on the Thames for supplying electricity, and that they proposed to have a depot for that purpose at Weybridge. The company's offer was irrespective of any house lighting whatever. If householders made use of the facilities it would reduce the cost of the public lighting. The chairman said he understood the offer of the company was that they would put up in Weybridge 100 lamps at their own cost, supply them with electric light all the year round up to 1.30 a.m., the charge to be 45s. per lamp per annum. He thought it an extraordinarily liberal offer, and one which they should accept. Mr. Maud thought that 100 lights spread all over Weybridge would be simply wasted; that the price mentioned was ridiculous, and that double the money could not possibly do it; and that if the firm carried it out it was not worth while accepting an offer which would ultimately result in a monopoly. Mr. T. Hawkins did not think that, whoever the lighting inspectors were, they would enter into a bad contract. He suggested that the lamps should be placed closer together in streets than in places where there was not much traffic. After a lengthy discussion nine inspectors were elected—Dr. Sealy, Major Travers, Messrs. G. Jarvis, T. Dix, Young, Nias, Chambers, T. Hawkins, and Wood—the whole of whom, in answer to the chairman, expressed themselves in favour of electric lighting. Another resolution was passed empowering the inspectors to make further enquiries, and limiting the sum to be expended by them to £230. The system proposed to be adopted by Messrs. Laing, Wharton, and Down is the incandescent lamps in series. It is understood that the lighting inspectors will also invite tenders from other firms.

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THE RELATIVE ADVANTAGES OF SERIES AND PARALLEL WORKING ON ELECTRIC TRAMWAYS.

The enterprising spirit shown by the Series Traction Syndicate in starting the Northfleet line at their own cost and responsibility merely to publicly demonstrate the practical merits of their system cannot fail to be appreciated by all those who are interested in electric propulsion. At the same time this very interest should lead electricians to a more searching investigation into the claims put forward on behalf of this particular system of working. The argument by which the superiority of the series over the parallel system is sought to be demonstrated is exceedingly simple and, on the whole, plausible enough. We are told that the difference between the two is comparable to that existing in electric lighting. The Gulcher Company arrange their arc lamps in parallel between mains carrying some 60 or 65 volts, and if the number of lamps is considerable, and the area to be lighted extensive, the weight of copper in the mains becomes a very serious item, far greater than would be required were all the lamps arranged in series as is customary in the Brush or Thomson-Houston systems. In the same way, argue the supporters of the series system of tramway working, does this system effect a considerable economy in copper as compared with the parallel system. So plausible as this analogy appears, it has the fault of many other analogies to be misleading. The conditions in the two cases are by no means comparable. On the one hand, the pressure at which arc lamps are worked in parallel is very much smaller than that which can be conveniently applied to the working of motors, and, on the other hand, the pressure on the terminals of an arc light machine intended for a large number of lamps in series is far greater than any responsible engineer would care to employ in connection with the conductor of a tram line when this conductor must be placed into an underground channel, as is done in the system promoted by the Series Traction Syndicate. There is also another consideration which should be borne in mind. Electric tram lines for urban or suburban service are necessarily short, and in this country, at any rate, cannot be worked on any overhead system. The choice, there fore, lies between the conductor system with underground channel and storage cells. Where the traffic is light, the earning power of the line is too small to render the employment of an underground channel—the cost of which is almost independent of the size of the conductor as determined by the exigencies of the traffic—economical, and in this case storage cars offer the best solution of the problem. With a heavy traffic the underground conductor is, of course, more economical than either storage or steam cars, but only on short lines in towns. On long lines running across country no kind of electric car can compete against the train system worked by steam locomotives when the traffic is heavy, whilst for light traffic the overhead conductor system or storage cars may be more economical than steam, but the underground conductor system is obviously out of the question on account of its great first cost. Moreover, on lines across country this system offers no advantage as compared with the overhead system, and need therefore not be further considered in this connection. The question between parallel and series working of electric tram lines is thus narrowed down to a comparison of the two systems as applied to short lines on which the cars run at frequent intervals.

To avoid dealing in generalities, we propose to consider a definite case. Assume a line of four miles in length, with a five minutes' service of single cars. At a speed of from seven to eight miles an hour there will thus be about eight cars in motion, and the average power for each car may be roughly assumed as 6,000 watts, making a total of 48,000 watts, to be supplied by the generating station, irrespective of the losses in the conductor by leakage and resistance. In order not to complicate the calculations, we propose to neglect these losses for both systems, as far as the generating station is concerned, but putting the condition that they shall be equal for both. The generating station we assume to be established in the middle of the line. Considering, first, the parallel system, we must assume a safe and convenient pressure to work at. The pressure depends, to a great extent, on the possibility of insuring permanently a high insulation, but it is also limited by the difficulty of constructing small power compound or shunt motors for very high terminal pressures. Now, the power required from a tram motor varies, of course, continually with the state of the road, gradients and speed, and if the whole of the journey were performed at the highest speed of, say, eight miles an hour, the energy required may, on steep grades combined with sharp curves and a bad road, amount to 30 h.p., but on an average line the bulk of the work will be done between 5 h.p. and 8 h.p., and it is for the economical development of this amount of energy that the motor should be designed, although it must at the same time be capable of exerting a torque corresponding to 30 h.p. at full speed. Now, a motor designed for 8 h.p. is, after all, a small machine, more suitable for low than high voltage; and taking this into account, we think that most electrical engineers would not care to make such a machine for a pressure much exceeding 400 or 500 volts. Let us assume the lower of these figures as the standard pressure at which the parallel system is to be worked. Each car will then require a current of 15 amperes, and the total current flowing from the centre of the line, right and left, will be 60 amperes for each half. A five minutes' service could, of course, not be worked on a single line in both directions, and there will be a second line required, but this, as equally the case with the series system, we need not take into account. The insulation resistance of the conductor with a parallel system may be very high, as metallic parts of it need only be exposed at intervals, the rest of the conductor being capable of the highest possible insulation. We shall probably be within the mark if we assume the insulation resistance to earth of the underground conductor to be at least 2,000 ohms per mile. The resistance of a cable ¼ square inch in section may be taken as ·18 ohm and that of the return circuit through earth and rails as ·25 ohm per mile. Without going into any elaborate calculations, it may be assumed that the total loss of pressure due to resistance on each half of the line is equal to that which would take place if the current of 60 amperes were to flow a mile out and a mile home without being tapped on the way. This gives a total loss of 26 volts, or 6½ per cent. of the standard pressure. The total leakage resistance is 500 ohms, and the loss of current from leakage ·8 ampere. This is so trifling an amount, that it is practically without influence on the efficiency, and on that account might well be neglected. Yet, with respect of the maintenance of insulation, this leakage, small though it be, cannot be neglected, and must, indeed, form one of the items of comparison between the two systems under consideration. It may be stated as a general proposition that the amount of current allowed to leak to earth in any system of current transmission determines the rate at which the insulation will be destroyed, and to put the two systems upon an equal footing we must therefore arrange matters so that the leakage shall be the same in both. It may well be doubted whether a method of construction which requires the employment of "spring jacks" every 20 feet or so can give so high an insulation resistance as the cable used in parallel working; but we will give the series system the benefit of the doubt, and assume that the total insulation of the conductor to earth, spring jacks included, is also 2,000 ohms per mile. Under these circumstances it will be permissible to work the line at such a pressure that in no part of the conductor shall there be a potential greater than 400 volts either above or below that of the earth. We may therefore arrange to have a total difference of potential between the two ends of the line of 800 volts, or twice as much as in the series system. To get equal efficiency of conductor, we may also allow twice the loss, or 52 volts. Now, the total length of conductor is in this case eight miles, and the current passing along this whole length is 60 amperes. The resistance of these eight miles of conductor must therefore not exceed ·87, or, say, ·11 ohm per mile, and this requires a cable of about ·41 square inch section. It will thus be seen that the amount of copper required per mile of conductor is actually some 60 per cent. greater in the case of the series system, as compared with the parallel system, whilst the length is doubled.

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The total weight of copper is therefore in the two systems, as 1 to 3·2. It might, perhaps, be objected that by placing the generating station into the middle of the line we have too much favoured the parallel system. Had we placed it at one end, the amount of copper required for this system would have been four times as great, whilst it would have made no difference to the series system. In this case the latter system would enable us to save some 20 per cent. of the copper, but against this saving must be put the cost of the spring jacks and other appliances which the complicated nature of the whole scheme render necessary. It is thus very doubtful whether even under the most favourable circumstances the series system has any real economic advantages over the far simpler parallel system. On the other hand, it has some very obvious technical disadvantages. In the first place, the large number of movable spring contacts inserted into the main conductor forms a very palpable danger of interruption of continuity because multiplying the number of points at which something may go wrong. In the next place, the maintenance must be a heavy item, and last, but not least, the starting power of each car is limited in the same way as it is limited in a steam-driven car. The current being constant, the maximum turning effort of the armature spindle is evidently determined by the strength of the field, and the limit of this is quickly reached. With a motor coupled across the mains, on the other hand, the turning effort may almost be indefinitely increased, because, with a constant field, it is proportional to the current flowing through the armature, which, as long as the car is at rest, is only limited by the very small resistance of the armature. The parallel arrangement affords, therefore, greater security against sticking on the line, and altogether a more absolute control of the cars.

DISTURBANCES ARISING FROM THE USE OF "EARTH" FOR ELECTRIC LIGHTING PURPOSES.*

BY W. H. PREECE, F.R.S., PAST PRESIDENT.

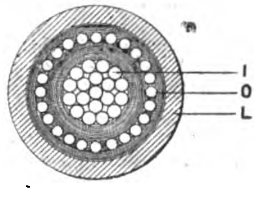
The magnetic field produced by a current flowing in a straight wire, and returning through the earth, extends to such distances that it is quite impossible to say where or when or how a telephone circuit in that field would be disturbed by any changes in that current. It is quite certain that if a single conductor between Deptford and London were subject to rapid alternations under a potential difference of 10,000 volts—the current returning by way of the earth—every telephone circuit in the metropolis would be disturbed, and probably rendered unworkable. The law determining the distance to which this influence extends was given by me in a paper read before the British Association at Manchester in 1887. It is given in the following equation:

$$C_2 = \frac{C_1 l}{d^2 r_2} \times M;$$

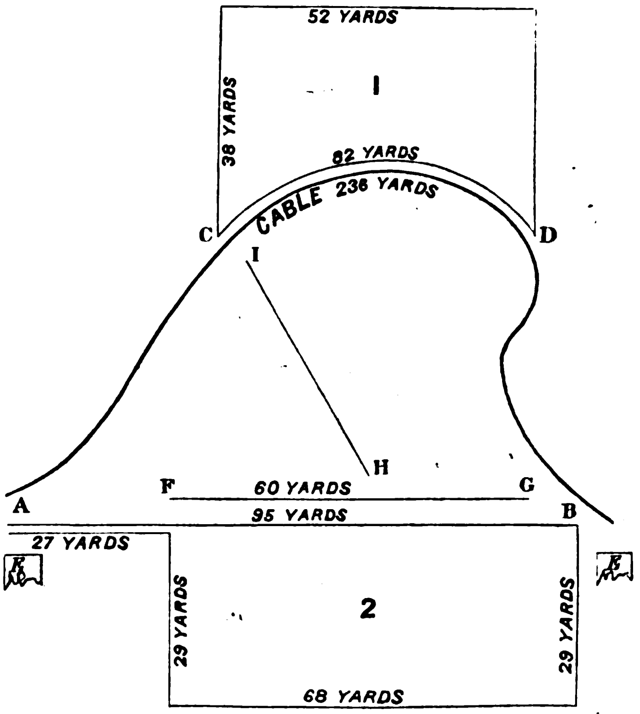
C_1 being the primary currents, C_2 the secondary currents, l the length of the primary, d the distance between the wires, r_2 the resistance of the secondary, M a constant dependent on the frequency of the primary currents and the rate at which they rise and fall.

It follows from this formula that currents of rapid frequency on a conductor 10 miles in length, carrying 100 amperes, might be evident at a distance of 19 miles. It becomes, therefore, important to decide to what extent disturbing influences can be eliminated. It is well known that if either the disturbing circuit or that disturbed be constructed of two wires so close to each other and so erected that the mean average distance between the disturber and the disturbed is the same, no inductive effects are evident, for the influence on one wire is entirely neutralised by the equal and opposite effect on the other. But if this mean average distance is not equal, or if the equality of the two currents be departed from, then a disturbance will arise which will depend on the difference between the two currents and their relative distances. Hence the most perfectly silent telephone circuit becomes noisy when leaks occur in the insulation, and hence it is that the earth plays such an important part in the efficiency of the system.

It was reported in the technical papers that the London Electric Supply Corporation contemplated laying a concentric conductor between Deptford and London, with the external copper conductor in contact with the earth. As it seemed to the Post Office authorities very doubtful whether such an arrangement would be free from disturbance, experiments were made to test the point. The experiments were made by me in an open space of two or three acres in extent. A concentric cable was constructed so that the outside and enveloping conductor could be insulated or not. The inner conductor was composed of a strand of 19 No. 15 B.W.G. (72 mils.) copper wires. The outer conductor completely surrounded the inner, and consisted of 24 No. 16 B.W.G. (65 mils.) copper wires. Each conductor weighed about 1,600lb. per mile, and gave a resistance of ·56 ohm. The outside sheath was of lead. The following is a full-size section of the cable:



The following diagram will explain the arrangement of the wires:



Two earth-plates were buried at the points A and B, and between them a No. 7 guttapercha wire was laid along the ground, telephones being inserted at each end. The electric light cable was laid between the same points by a circuitous route, as shown. At the points C and D two earth-rods were driven in, and another No. 7 guttapercha wire was laid outside the area enclosed by, and about a foot from, the cable.

Beyond each of the guttapercha wire, extension wires were carried to enable metallic loops to be made up, forming approximate squares (1 and 2 on diagram).

Experiment 1. A Wheatstone transmitter placed at B was connected to the inner conductor, I, of the cable, the lead sheath, L, being used as the return wire. Reversals at top speed (a frequency of 80 per second) were sent through the cable from an E.M.F. of 20 volts, the current strength being about 1·3 amperes. Loud disturbance was heard in the telephones at A and B when the transmitter was running.

Experiment 2.—Earth-bars were driven in at the points F and G, and connected by a wire and telephone. Currents were picked up by the telephone through this section, their effect being apparently quite as loud as between A and B.

Experiment 3.—The points H and I were similarly connected, and with a like result.

Experiment 4.—The points C and D were next connected by the wire attached to the earth-bars, a telephone being inserted at D. Disturbances almost as loud as on the circuit A B were heard.

Experiment 5.—The wire C D was disconnected from the earth-bars, and a metallic circuit forming an approximate square was made up (1 on diagram). The interference was still heard, but was only about half as loud when the earth was used at C D.

Experiment 6.—The insulated outer *conductor*, O, was substituted in place of the lead sheath as the return wire, and the disturbances in the loop C D ceased entirely.

Experiment 7.—The outer conductor, O, and the lead sheath, L, were coupled together, forming jointly a return wire in contact with the earth. The disturbance in the metallic square, 1,

* Paper read before the Institution of Electrical Engineers, Feb. 28.

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reappeared, but was reduced in loudness to about half that in the fourth experiment.

Experiment 8.—The cable was next laid out straight from A to B, the telephone wire being parallel to it. When the lead sheath was used as the return wire, loud disturbance was heard in the telephones at A and B. When the lead sheath and outer conductor were jointly used as the return wire, the noise in the telephones was greatly reduced (to about one-fourth).

Experiment 9.—To prove that the result obtained in the last experiment was due to earth conduction, a metallic square (2 in diagram) was formed, and the disturbance in the telephones disappeared.

It follows from these experiments that the disturbance of the potential of the earth at A and B, and the establishment between these two points of a potential difference, cause currents to flow through the earth between A and B which destroy the equality between those in the inner and outer conductor of the concentric cable upon which equilibrium depends. It is, therefore, quite clear that the use of the external sheathing, as part of the conductor in contact with the earth is quite out of the question; whereas, if the enveloping conductor be insulated, it is quite innocent of disturbance, and would not intefere with neighbouring telephones.

The question has arisen as to whether the currents experimented with—viz., those produced by a Wheatstone transmitter, are of the same character as those produced by an alternating-current machine. The frequency in the two cases may be alike. Taking the frequency at 100, it will follow that each current, whether it be of the Wheatstone transmitter or of the alternating-current machine, will rise from zero to maximum and fall from maximum to zero in ·0025 second. The strength of current generally used in the Wheatstone transmitter is 50 milliamperes, while that of an alternating-current machine may amount to 100 amperes; and since most of the Wheatstone circuits in this country are long circuits, upon which the resistance and the capacity are considerable, it is quite evident that in actual practice the rate at which the current rises and falls is greater in the case of alternating-current machines that in the case of the Wheatstone transmitter. The fact that it is so is sufficiently proved in actual practice. Before the Grosvenor Gallery Company established their present metallic loop system, all the telephones around and about Bond-street were disturbed. In order, however, to settle the matter, I have carefully experimented with the currents produced by the alternate-current machines at West Brompton and at Eastbourne, and I find that it is quite impossible to detect any difference between the effects of Wheatstone transmitters and alternating-current dynamos.

These experiments, taken alone, are sufficiently definite to ender it decisive that the use of the earth in such instances cannot be allowed; but it may happen that in other systems of distribution where the currents are continuous and steady, such as the systems by which it is proposed to distribute by means of batteries, the earth, under exceptional circumstances, may be permitted.

THE TRANSMISSION OF POWER BY ELECTRICITY.*

BY FRANK J. SPRAGUE.

(*Continued from page 273*).

8. As a modification of the proceeding, especially where large powers, long distances, and necessarily high potentials are used, it is advisable to divide the generators and motors into a battery of machines of identically the same weight and character, the number of the machines being the ratio of the electrical efficiencies, the generators all to be driven from the same line of shafting, and the motors to drive on to a common line, and the current to pass through all the machines in series. This I consider the only sound method when dealing with large powers and high potentials and single units of generation and recovery, especially where automatic regulation is required. Its advantages are manifest. One of the greatest difficulties which we have in dynamo-electric construction in closed circuit machines, especially where using the drum system of winding, is the difficulty of securing perfect insulation when high potentials are used.

One thousand or 1,200 volts seem as high as it is now advisable to go in machines of this type, where currents of any magnitude are to be used. In the transmission of electricity, reliability is an essential, and a potential of 3,000 or 4,000 volts, distributed over three or four machines in series, is, despite the increased number of machines, far less liable to cause failure than where put into one machine of the aggregate size of the four; and in the event of the breaking down of one machine, the units may be so proportioned that by a corresponding change in the units at the other station, or a proper variation of the regulating shunt to the fields, it becomes quite possible to continue automatic operation. As an illustration of this distribution of machines, if wishing to use dynamos and motors of an electrical efficiency of about 95 per cent., a commercial efficiency each of about 90 per cent., and with about 60 per cent. as the total commercial efficiency of the circuit, I would, with a distance of about nine miles, use five series machines identical in construction, each wound for about 1,200 volts, three of which machines would be driven by a common line of shafting at the generating station, and two driving on to a common line of shafting at the receiving station. It will be noticed that both in the single and multiple unit series system, the E.M.F. and the current vary equally. I hope at an early date to be able to show this last system in practical operation.

The indirect methods of transmission, such as through a secondary battery of generators, motor generators, and secondary batteries, I will not here discuss.

I come now to the consideration of some new, interesting, and very practical formulæ for determining the elements of a single transmission of a given amount of power. Before entering upon its discussion, it is necessary to state why I differ somewhat from the methods which have hitherto been published.

Those who have followed with any particular interest the progress of the development of the transmission of power by electricity, must be more or less familiar with the early experiments of Deprez and the papers by Prof. Lodge and Mr. Gisbert Kapp. The experiments of Deprez have not had that practical result which had been hoped for them, and it seems to me as if an attempt had been made to go further than commercial demands warrant. We must avoid the consideration of the subject from a purely theoretical light. No system of transmitted energy can be made profitable unless the cost of the same at the far end, including not only the actual cost of production but the capitalised value of the possibility of accident due to the fact that the prime source of energy is not under immediate control, shall be less for the transmitted energy than the price that would have to be paid for its production there by water, steam, or some other agency. As attractive as the use of water-power appears as a prime source of energy, its uses are very limited, and every year will become more and more so; and unquestionably the great future of the transmission of power by electricity will depend upon the fact that in a large proportion of cases it will be cheaper to carry energy in the shape of electricity on a wire by the shortest cut between two points than to pack it up in the shape of wood or coal on the back of mule or behind a horse. I have no sympathy with the theoretically possible, but really impracticable consideration of the transmission of power, from Niagara to New York; for Niagara has a far greater value as a sublime spectacle than as a commercial factor in metropolitan affairs. I will then, in my estimates, confine myself to that which is practical and possible, and will consider the conditions under which power shall be so transmitted. Messrs. Lodge and Kapp have deduced some very interesting formulæ, but one of the conditions which was taken into account by them was that of leakage. In a purely theoretical study this is as it should be; but the transmission of power by electricity to meet the demands of actual life must above all things be reliable; and by this I mean, not merely certain to supply power at the end of the line, but to deliver a definite percentage under perfect regulation and a known cost. This cannot be done with the uncertain and variable element of an unknown but material leakage; for if this leakage exists, then it must be a variable quantity depending not only upon the condition of weather but likewise upon the continual variation which exists in the E.M.F. when the load is not constant. We meet, then, with the condition that in the successful installation of a plant for the transmission of power, we must be free from material leakage; that is, the leakage must be so small under all possible conditions of service as to never interfere with the efficiency and reliability of the transmission. Hence, in the formula which I in practice adopt to determine the elements of my work, I shall assume a line of practically perfect insulation. I am justified in this because the additional expense to secure this desirable result is more than compensated for by the reliability of the service. We can only accomplish this by the most careful line erection and choice of insulators. It can be materially aided by running the positive and negative leads each on an independent line of poles, and perfectly clear of all trees, and, of course, a well-covered wire can be used. When a double line of poles is used, it is advisable to wrap the lower ends with bare wire for a distance of about 6ft. above the ground, and to connect these bases together; or, if the poles are close together, a galvanised iron or copper wire should be taken around each pole at the distance given and joined together. This is to avoid the possibility of a serious shock in wet weather, which might be received by a person leaning against a wet pole if any accident should occur to the line insulators when very high potentials are used.

In the formulæ which are given, I shall make use of the term "couple efficiency." As long ago as the spring of 1888, Drs. John and Edward Hopkinson made tests of efficiency of double conversion with the Edison-Hopkinson and Manchester

* A lecture delivered before the Franklin Institute, November 12, 1888.

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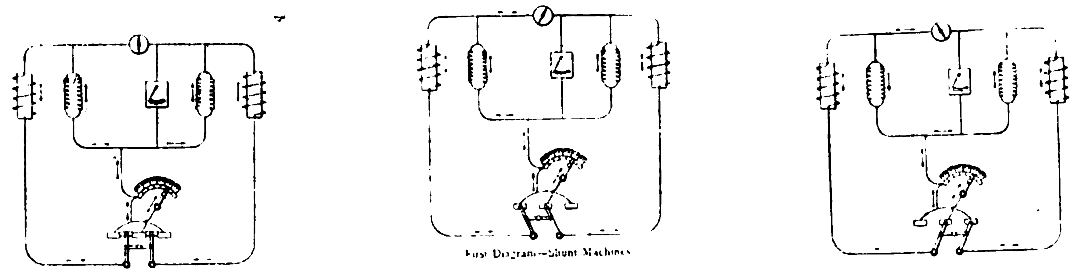
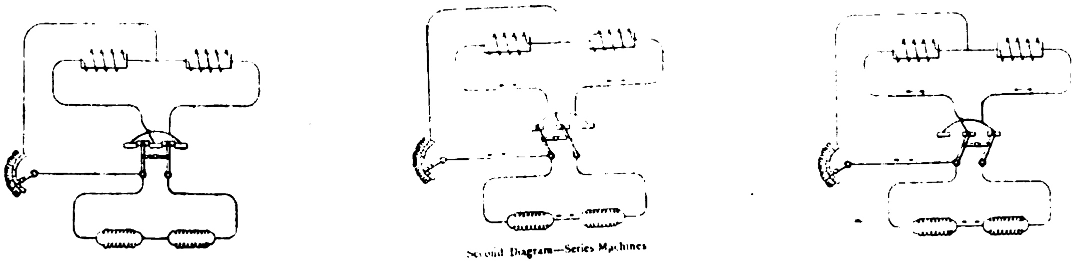
dynamos, the efficiency of the former rising at times to over 87 per cent., and of the latter to nearly 78 per cent. No others have made so thorough an analysis of the action of dynamo-electric machinery, and my own experience warrants me in assuming, for the purpose of this paper, a commercial efficiency of double conversion, where two machines are connected by a metallic circuit of no appreciable resistance, or what I have called the "couple efficiency," of not less than 80 per cent., which is only allowing about 90 per cent. commercial efficiency for the dynamos and motors. It will oftentimes rise higher than this, but I think it advisable in a specific formula to adopt a perfectly safe figure. This couple efficiency for either single, shunt, or series machines, or nests of machines, is easily determined with considerable accuracy and small expenditure of power. The method I prefer was one independently proposed, but similar to that first put into practice by Dr. John Hopkinson, that English scientific investigator to whom we all owe so much. It may be termed the variable differential method, and depends upon the use of an electro-mechanical couple. The first diagram illustrates the testing of two shunt-wound machines. Two such machines are belted to a common line of counter-shafting, having three pulleys, each being given its proper speed. dynamo. This reversal is not instantaneous, because it takes time for the field-magnets to charge and discharge. The ampere-meter will drop to zero, and will then rise again progressively.

This method of testing can be used for two purposes, one for testing the actual horse-power developed, and the couple efficiency, which can be done by measuring the current E.M.F. between the machines and the horse-power delivered to the shafting by the third motor, and for the other purpose of testing simply the heating capacity of the armature-coils with a given number of amperes. For this latter purpose it does not matter practically whether the machines are run at their normal speed and generate their normal E.M.F., or whether some lower E.M.F. is used. If a lower E.M.F. is present, it simply means that there must be a greater ratio of difference between the field-magnet strengths and a larger resistance used with the reversing switch.

When desiring to test the two series machines, the connections are somewhat different, and are illustrated in the second diagram; the machines, of course, being mechanically connected as in the first instance. We can similarly test a multiple unit series system; and in all these cases, by the introduction of an



First Diagram—Shunt Machines



Second Diagram—Series Machines

To the third pulley is connected a motor of about one-third the capacity of one of the machines to be tested, this motor being one of a perfectly well-known commercial efficiency, and provided with means for varying its speed; or, if desired, the power can be transmitted through a good dynamometer. The like terminals of the large motors are then connected together, an ampere-meter put into this circuit, and a potential galvanometer connected across the terminals. One terminal of each field is likewise connected to its proper line, and the other terminals of these fields are brought to the movable levers of a two-way circuit changing switch. One contact is carried to the main line, and between it and the other two is inserted a variable resistance, which in the middle position of the switch is short circuited. We have, then, the two large motors connected in an electro-mechanical couple, and to the same shafting is connected a third motor. The main dynamo being started, the switch set in the middle position, the motor is speeded up, which sets the countershafting in operation, and drives both the machines as dynamos, each exciting its own field. If the machines are symmetrical, no current whatsoever will pass over the branch connecting the two; they are simply in the position of two dynamos in parallel circuit with each other, with no external circuit, and no path over which the current can flow except that through their field-magnets; consequently, very little power, save that of friction, is taken. The switch being moved in one direction, the resistance is thrown into the field of one machine. The E.M.F. which it develops at this particular speed is now reduced; it becomes a motor, and current will flow over the connecting mains from the other machine, which is still a dynamo, which current is roughly expressed by the quotient of the difference of the E.M.F.'s of the two machines, divided by the resistance of the circuit. By varying the resistance in the fields this current can be made of any value up to the limit. We have here, then, one machine acting as a motor, and driving on to the counter-shafting with a certain number of horse-power, this counter-shafting driving the other machine as a dynamo with a certain greater amount of horse-power, this second machine furnishing the current which operates the first as a motor. The deficit, or loss of efficiency between the two machines and the friction, is supplied by the third. By reversing the switch the resistance is first cut out of one field, and then thrown into the field of the other machine. This machine now becomes a motor, and the other machine becomes a artificial resistance into line, we can produce all the phenomena of an actual long-distance transmission. This method of testing, where there can be an immediate variable and controllable reversibility of the dynamo and motor, and test of the efficiency of transmission under widely varying conditions, illustrates in one of the most beautiful ways the flexibility and utility of electric transmission.

Assuming, then, that we have no leakage, and that our dynamos and motors have a definite known efficiency, we will take up the consideration of a few formulæ.

Let l = distance between the generating and receiving stations in feet, plus the sag.
n = number of effective horse-power to be delivered on the motor shaft.
E = E.M.F. at the terminals of the motor.
v = number of volts fall of potential on the line.
E + v, or E′, being, of course, the E.M.F. at the beginning of the line or the terminals of the generator.
a = efficiency of the motor.
C M = circular mils of conductor.

An E.H.P. is 746 watts, watts being the product of current by E.M.F. Then for any horse-power, n, a motor efficiency of a and an E.M.F. of E at the motor terminals, we have the number of amperes equal to

$$\frac{746\, n}{E\, a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

Allowing m ohms as the resistance per mil-foot of copper, the total line resistance would be

$$\frac{2\, m\, l}{C M}$$

for a complete metallic circuit. From the above we have for the drop or fall of potential on the line

$$v = \frac{746\, n}{E\, a} \times \frac{2\, m\, l}{C M} = \frac{1{,}492\, n\, m\, l}{E\, a\, C M}$$

or

$$C M = \frac{1{,}492\, n\, m\, l}{E\, v\, a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Substituting for m its approximate value, 10·5

$$C M = \frac{15{,}666\, n\, l}{E\, v\, a}.$$

(To be continued.)

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THE

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NOTICE.

During the course of the past year we issued steel engraved portraits of Mr. E. Graves, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. Wollaston, M.D., F.R.S., *and* Sir Humphry Davy, F.R.S. *The portraits of* Prof. D. E. Hughes, F.R.S., *and of* Dr. J. Hopkinson, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

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TELEPHONIC AMALGAMATION.

Our interests do not tend much in the direction of telephony or telegraphy, but they are large branches of electrical engineering, although the engineering might be termed a delicate kind. Telephony in engineering matters stands to electric lighting somewhat as watchmaking in mechanical engineering does to locomotive building. At the present moment, however, if not from an engineering, at any rate from a commercial point of view, the action of the large telephone companies as shadowed forth in the daily papers is of extreme importance.

According to the most recent information, the principal telephone companies of the kingdom are to be amalgamated. This means, if it means anything, an absolute monopoly. The word does not frighten us, as in this case, among others, we firmly believe, and have constantly given expression to that belief, that telephony to be successful must be a monopoly. Our opinions have differed from those of many people, in that we thought and think that the monopoly ought to be in the hands of the Government and not in the hands of a company. The reasons for this opinion have been frankly and freely given. The nation acquired at a high price, some say at an exorbitant price, the telegraphic system of the country, and before they had really made the purchase pecuniarily successful came the invention of the telephone, and within a year or two proof positive of its success commercially. Telegraphy then had to fight against the younger introduction, and it also had to suffer from an agitation which resulted in the lowering of the tariff. Altogether, then, the telegraphs have, in the hands of the Government, had a hard time of it. We desire to exonerate the permanent officials from every suspicion of inability to realise the exact state of affairs. They are powerless when political strings pull the instrument. They cannot act, and can hardly advise, upon purely business lines. We assume

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they are compelled to trim their operations to fit into the peculiarities of the situation.

Another point to be remembered is that telephony is held to be telegraphy under another name, and that the Government derive a revenue from licenses. The great question is, whether the revenue so obtained compensates for the loss of revenue due to competition? In our opinion it does not, and we contend that the difference against the Government will largely increase as telephony becomes generally adopted and carried on in a more business-like manner. No doubt the amalgamation of the companies will tend to introduce new blood into the management of the United, and, perhaps, tend to induce that corporation, or the new corporation, to work a little more in harmony with the wishes of its customers. Taking it for granted, then, that amalgamation means the installation of telephones throughout the length and breadth of the land—to be used as extensively as possible over as long distances as possible—one question the public will ask is, whether time and trouble can be saved by telephoning, instead of telegraphing. As regards the question of time, there may be doubts. Frequently with metropolitan messages it takes longer to "get through" than to send a boy. As regards the question of distance combined with time, we are inclined to think the telephone will ere long beat the telegraph. It has been assumed that telephony is impossible, under certain climatic conditions, over long distances. It has, however, been shown that the distances over which it can be worked are such as will make it a dangerous competitor to telegraphy; for a conversation of half a minute, a verbal statement, instead of a telegraphic one, will often facilitate business. A technical explanation can be given by telephone in a few minutes that could not be given by a telegram, and would take much longer and cost more if sent by letter, while time will be saved as against the latter, and, so far as accuracy is concerned, the telephone has the advantage, for the message can be repeated again and again till it is understood.

Every consideration, therefore, points to monopoly. There cannot be a number of companies roaming about over the country at their own sweet wills, erecting posts and wires, and obtaining compulsory powers. The value of the telephone is lessened by division. The more subscribers the greater the value, and it will not do, from a business point of view, for Jones to be on one exchange and Brown on another.

It is just possible that the promoters of the monopoly in the last days of the telephone patent may be thinking that the Government must sooner or later take over their work. We imagine they are not far wrong, and that this question has been considered in the proper quarters. If, however, the Government does not act at once before the trunk lines are erected, they will either have to pay another large bill to take over the telephone system, or leave the work entirely in the hands of private individuals. In the former case the direct money loss is easily seen, in the latter not so easily, as it comes gradually in the diminishing receipts from the telegraphs, or in a too great diminishing increase in such receipts. Whatever be the action or inaction of the Government, we shall advocate the extension of the telephones in every conceivable direction. The world is not to stand still because Governments fail to recognise the possibilities of new inventions, and whatever may be their ultimate intention the amalgamation of the telephone companies is an act which commends itself to every business mind, and we can only say, Go on and prosper.

The prosperity of anything that tends to enable men to transact business quicker, and with fewer liabilities to mistakes, must necessarily benefit the whole nation. Telephony is an invention of this character. Its development and utility under proper management is not understood, and cannot be understood, till it becomes a far commoner instrument than it is at present. Now a luxury in even business houses, it should rapidly become a necessity in every house. The exchanges will have to be opened day and night till they are got rid of altogether by some automatic arrangement to enable any subscriber to place himself in communication with any other subscriber should the latter's instrument be disengaged. It would not be very difficult to construct such an apparatus even now, but it would be far too costly to be considered commercially.

THE BENTLEY-KNIGHT TRAM.

We herewith illustrate the latest form of the Bentley-Knight motor truck and conduit. Fig. 1 shows an end view of the motor truck, and Fig. 2 a sectional view. The conduits for a double track are laid in the space between up and down tracks, examples of which are to be seen in Boston and New York. The advantages claimed are that every part is accessible, repairable, and replaceable from the street surface, and the width of the slot can be regulated at will, without interference with the pavement. The excavation required to lay conduits, as shown, is said to be much less than is usual. The space between the tracks—that is, where the conduits are placed—is the least-used portion of the street, the cleanest and the best drained. What with the combined energies of this company, of the Daft Company, of the Sprague, and other pioneers of electrical street railways, America has taken first place in this kind of work. One of the lines engineered by the Bentley-Knight Company shows how flexible their work is. The line is about four miles in length. For one-fourth of this distance the conductors are contained in a sub-surface conduit. For the remainder of the way the conductors are elevated above the roadway, bracketed off from poles erected along the kerb line on one side of the street. The conduit branches from double to single track, and at the terminus there is a conduit cross-over switch from down to up track. At different points along the conduit section, the conduit cuts through

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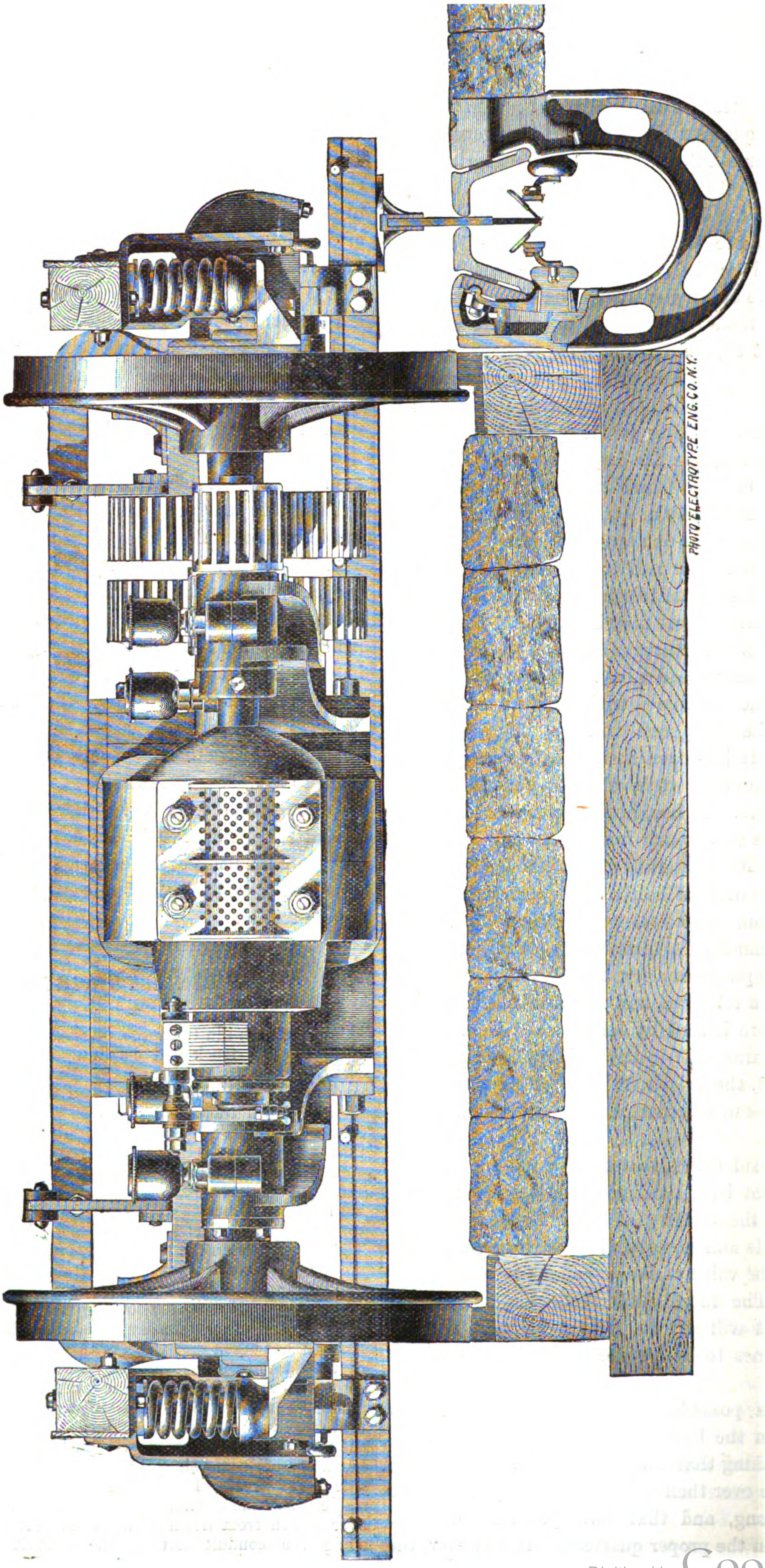
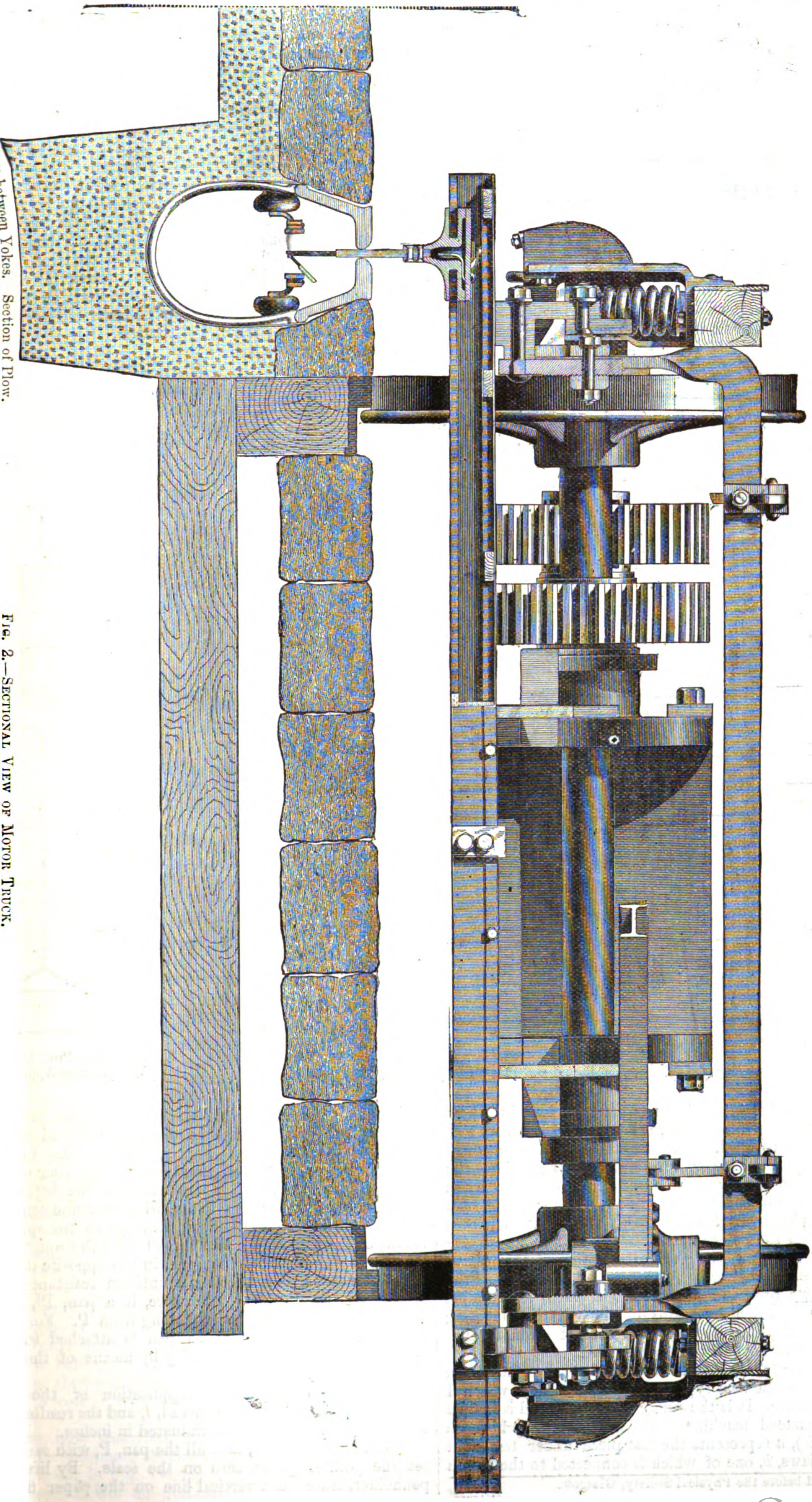
BENTLEY-KNIGHT ELECTRIC RAILWAY.



Conduit at Yoke. End View of Plow.

FIG. 1.—END VIEW OF MOTOR TRUCK.

BENTLEY-KNIGHT ELECTRIC RAILWAY.



Conduit between Yokes. Section of Plow.

Fig. 2.—Sectional View of Motor Truck.

five other street railway tracks belonging to other companies. This shows the kind of difficulties that can be overcome by the conduit system. We shall be glad when we can chronicle such work in England. Elsewhere we have critically discussed the series *versus* the parallel systems, not from any desire to place the one above the other, but with a view of arriving at the truth as to which is the better.

PECULIARITIES OBSERVED IN TESTING MATERIALS.*

BY W. CLELAND, B.SC.

The materials in common use, when under the action of stress, pass through two states of existence—the elastic state and the plastic state. Under the former we have Hooke's law (*ut tensio sic vis*) expressing the proportionality of stress and strain, but no law has yet been found to show such a connection while under the latter state. It is of this state that I wish to speak about particularly. As mentioned in the heading to the paper, I intend bringing before the members of the society some peculiarities observed when testing materials of construction, leaving it for those of a more philosophic turn of mind than I am to put their own construction on the points noted.

I purpose, first of all, to give a description of the instruments (I should rather say machines) used, then to note the external points observed during a test, next to examine what can be revealed by means of the curve connecting stress and strain, and, finally, pay more attention to that part of the curve beyond the elastic limit.

The testing machine represented in Fig. 1 has not been chosen as being the best type, but as the one with which I am most intimate. It is the single lever form, and is known as the Wicksteed machine. In the sketch (which is diagrammatic), *a* represents the test piece under test held by the two jaws, *b*, one of which is connected to the piston of the hydraulic cylinder, *d*, and the other to the lever, whose arms are c_1 and c_2. This rests on the standard, *e*, and in order to balance the pressure on the piston, which is transmitted through the test piece to the lever, a monkey weight or poise, *m*, can be run along the lever. In the machine under question *m* weighs one ton; ratio of the arms of the lever is as 50:1. The pressure on the ram is got by means of a screw pump, while the total load transmitted is 100 tons. The stress is ascertained by a vernier attached to the travelling weight and a scale fixed on the beam. When once we have read 50 tons; if we want to go beyond this, the weight, *m*, is run back to zero and a load of one ton hung at the end of the lever. In testing, all that is necessary is to keep the beam floating free of the stops, and this can be very conveniently done by regulating the supply of water and the rate of application of the load. In fact, when testing it is quite possible to keep the beam midway between the stops until near the end of the test.

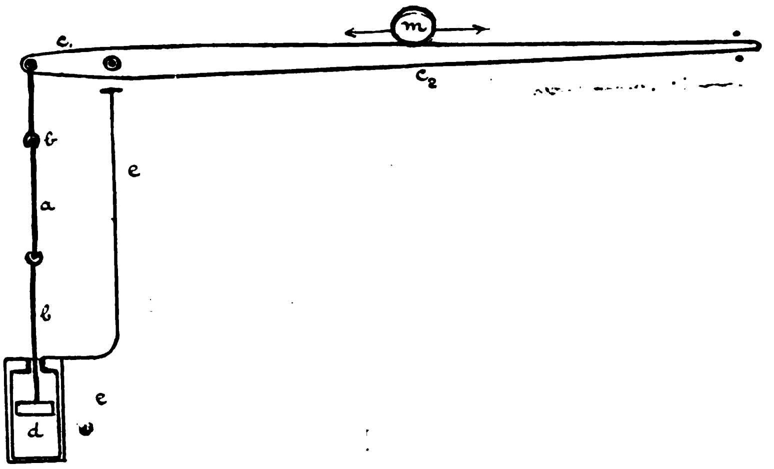


FIG. 1.—Wicksteed's Testing Machine.

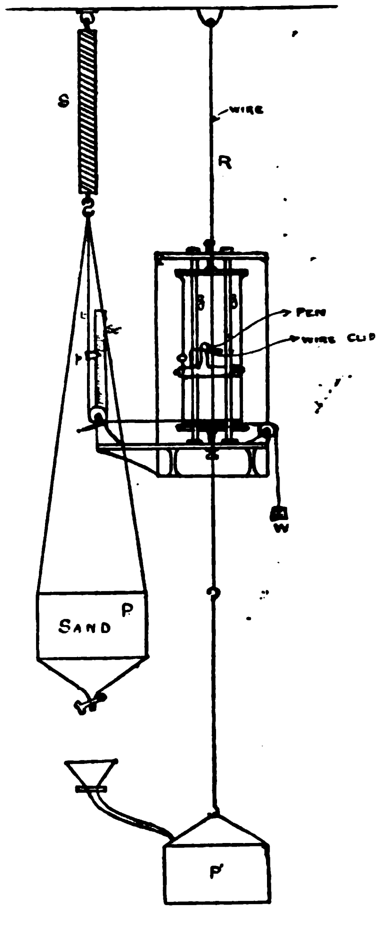
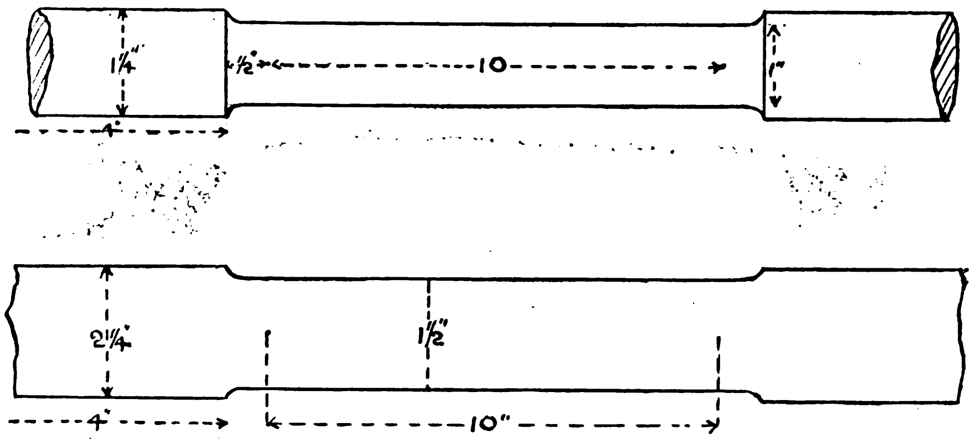


FIG. 2.—Prof. Barr's Wire-Testing Apparatus.

FIG III



Form and Dimensions of Round and Flat Test Specimens.

Some of the curves shown in this paper have been diagrammed by a wire-testing machine, designed by Prof. Barr. It is sketched in Fig. 2, and has the following action. S is a spring of known strength, from which is suspended a pan, P, with a stop-valve at the bottom containing fine sand. D is a drum, with very fine centres, so that it runs almost frictionless, attached to the spring by means of the thread, *t*. The thread, with the weight, *w*, at its end, is wound round the drum in the opposite direction to the thread, *t*, thus offering a uniform resistance to the motion of the drum. To the wire, R, a pan, P^1, is hung for the reception of the sand coming from P. For recording the strain of the wire, a pen is attached to it, the holder for which slides vertically by means of the guide-bars, *g g*.

To indicate the rate of application of the load a pointer, *p*, is attached to the thread, *t*, and the reading taken on the scale (Sc.), which is graduated in inches.

When making a test, first fill the pan, P, with sand, then set the pointer, *p*, to zero on the scale. By lifting the penholder, trace out a vertical line on the paper fixed on

* Paper read before the Physical Society, Glasgow.

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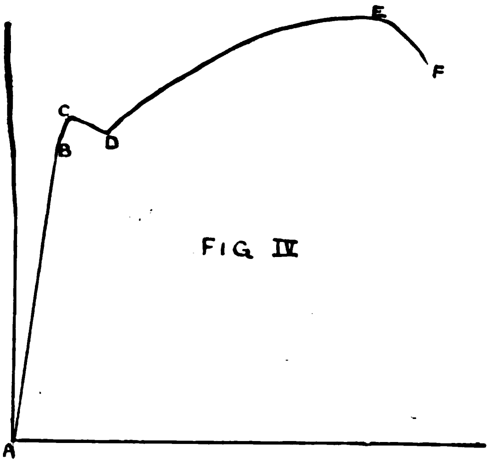
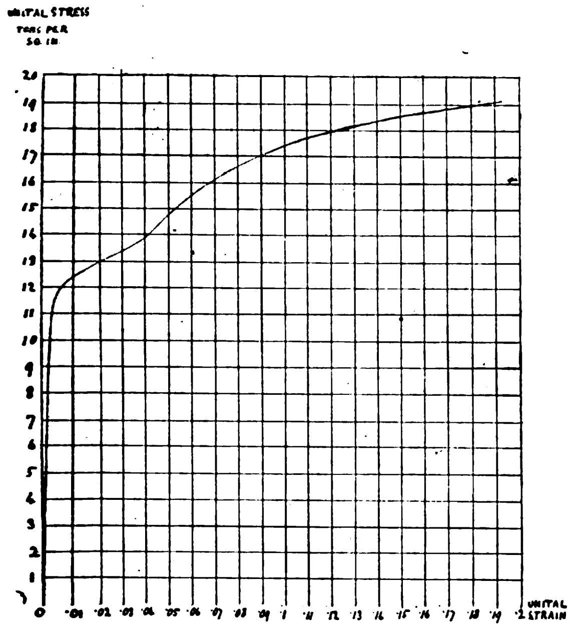
the drum. Turn the latter round a distance corresponding to the weight of the pan P^1, the hook, and the penholder. Then after clipping the penholder on to the wire, open the valve at the bottom of P, and allow the test to proceed.

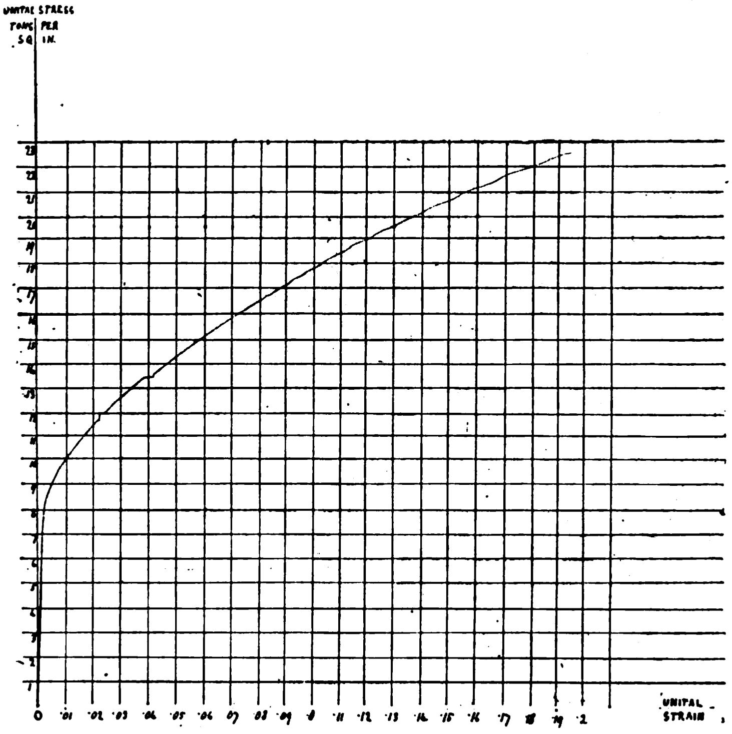


Fi 4.—Exag erated Form of th Stress rain Curve.

When finished, produce the straight part of the curve back to meet the straight line previously drawn. The scale for the curve is got from the known strength of the use of the metal from which the specimens have been taken. In describing the pecularities observed, it is necessary to select some material, as each material has its own characteristic, and mild steel having the greatest variety, I have chosen it. We will take a round specimen, and first mark two gauge points, 10in. apart. Divide this distance into half-inch lengths by circles drawn round the specimen. During the test, if we keep constantly measuring the 10in. length, we find that when a certain load has been reached, elongation occurs very rapidly, and that the elongation, which before this point was reached was almost nil, is now comparatively large. The stretching seems to be uniform along its length, as far as can be observed by means of the parallel lines. Now, however, the lever is seen to rest on the bottom stop, and the specimen begins to contract in diameter at some point. The load is run back, but it finally gives way at this place. (A portion of a test piece containing the local contraction is sent with the paper for the members to inspect.) If we apply the hand to this place while the specimen is under test, we experience an exhibition of part of the work done under the form of heat, and another part shows itself under the form of magnetism. After breaking, the specimen seems to be strongly magnetic. One peculiarity which shows itself very strongly in mild steel more so than in iron, is the coned form of the fracture. This is always seen in a more or less imperfect form in specimens of mild steel, and as far as I have observed it is



Autographic Test of Iron Wire. (Annealed.) Nov. 26, 1888. Length tested = 24·38in. Diam. = ·0178in. Area = ·00025 sq. in. Speed = 1lb. per 48 secs.



Autographic Test of Brass Wire. Nov. 17, 1888. Length tested = 28·25in. Diam. = ·017in. Area = ·000227 sq. in.

spring; for example, if the spring elongates ½in. for a load of 1lb., then ½in. on the diagram will correspond to a stress of 1lb. on the wire. It has been objected to this machine, that for practical purposes, or for purposes of comparison, that it is of very little use, as material in the form of wire is altogether different from the comparatively unstrained condition of the same material as used for purposes of construction. Of that there is no doubt, but still, from a coil of wire two pieces can be got much more similar in nature than when taken from a rod of iron. Besides, for the purpose of experimenting it is most convenient. Loads can be applied as quick or as slow as we please. Again, we are always sure that the results obtained under different conditions belong to different treatment and not to the specimens themselves, as specimens taken from different parts of a coil of wire are as near as possible practically identical.

Having now described the instruments used, we will turn to the specimens themselves.

The sketch in Fig. 3 shows the usual form and dimensions adopted, but the dimensions vary according to the the top part which has the projecting cone. Everyone knows that the fracture of a piece of iron is of more or less of a fibrous nature, while that of steel is crystalline in form. That can be seen from the specimen sent; but if examined closely, certain pittings are observed, which seem to be due to hard pieces in the steel. Now, this occurs very often, I may say without fail, in the specimens we have tested at the Yorkshire College, and to me they seem due to the mode of testing, for if another piece be taken from the same bar of steel and tested under different conditions, the pittings diminish in number.

Such are the features observed when steel is tested under ordinary conditions; and before proceeding to examine the external features when tested under different conditions, I will quote a passage from a paper on "The Flow of Solids," by M. H. Tresca (*Proceedings* Inst. of Mechanical Engineers for 1878):

"For all bodies two distinct periods are recognised: the period of perfect elasticity, which corresponds to variations of length proportional to the forces applied; and the period of imperfect elasticity, during which, on the

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contrary, the changes of dimension increase more rapidly than the forces producing them. If the second phase of deformation be alone considered, it is easily understood that it tends towards an ultimate condition in which a given force, sufficiently great, would continue to produce deformation, so to say, without limit—as may be observed in the process of drawing lead wire. This particular condition, in which the deformation is indefinitely augmented under the operation of a sufficiently great force, constitutes, in fact, the geometrical definition of a third period, which has been designated by the author as the period of fluidity. The period of fluidity is more extended for plastic substances; it is more restricted, and will even disappear altogether, for some vitreous or brittle substances. But it is perfectly developed and extremely extended in the case of clays and of the most malleable metals."

(To be continued.)

LITERATURE.

Electro-Deposition: A Practical Treatise on the Electrolysis of Gold, Silver, Copper, Nickel, and other Metals and Alloys, etc. By ALEXANDER WATT. With numerous illustrations. Third Edition, revised, corrected, and enlarged. Crosby Lockwood and Son. 1889.

This book is probably the most practical book on the special subject it treats in the English or any other language. Mr. Watt has made a life-long study of his subject, and his investigations have almost always been undertaken with the direct object of introducing something better into practice. What the practical world of electrolysis owes to his writings is best known to those engaged in the profession, but the mere fact that this large work has reached a third edition shows how much it is appreciated. In this edition we note that considerable attention has been paid to Cowles' process to obtain aluminium alloy. No book is perfect, and usually the index is a weak point. Here we have an unusually good index, but still imperfect. Wishing to test both index and the book, we looked for "Molloy," but his process for obtaining gold from its ores is not given. We hardly expected it would be, for the work is not directly metallurgical; but "gold" is indexed under p. 514, where we failed to find it. This is perhaps only said as a foil to what might be termed unstinted praise, for generally the greatest care has been taken to arrive at correctness, and if fault should be found it would be for the redundance rather than insufficiency of matter. Technical books are of two kinds: one purely scientific, appealing to the pure scientist; the other giving information to the unlearned in pure science. This book belongs to the latter class, and appeals more directly to the man who has to do the work than to the man who wants to find a chemical formula for certain reactions. It is unnecessary to say more of a book in its third edition. It has stood the test, and has not been found wanting.

BOARD OF TRADE ENQUIRY.

Major Marindin, C.M.G.R.E., on behalf of the Board of Trade, on Thursday week resumed the enquiry at the Westminster Town Hall for the purpose of hearing, on the part of a number of electric light corporations, their provisional orders to erect and maintain electric lines and works, and to supply electricity within certain areas in the metropolis and elsewhere, and the objections raised thereto by other companies and corporate bodies.

Continuation of the case of the London Electric Supply Corporation, Limited, which was represented by Mr. Pember, Q.C., Mr. A. K. Loyd, and Mr. J. C. Graham, instructed by Messrs. Deacon, Gibson, and Metcalfe.

Lord Crawford and Balcarres was recalled and cross-examined by the City Remembrancer.

Witness thought that the lighting of the City area would result in a good profit to the company. They proposed to enter the City at Cannon-street Hotel and Ludgate-hill Station. As he had said the previous day, he could not allocate any part of their capital for the City lighting. He did not ask a way-leave for their mains in the City for nothing, or without incurring the responsibilities incidental to such way-leave. If they did not accept those responsibilities, they were liable to be turned out of the area altogether. He thought that for street lighting the arc lights were preferable. As to the number of public lamps that would be required in the City, so far as he could gather from the specification issued by the City of London Commissioners, he found that there were three districts, and in the first of these there were 388 gas burners, in the second 526, and 633 in the third, making a total of 1,547. If they took a third of those gaslight burners, they would see that about 500 electric arc lights would supply the same light. He could not tell what number they contemplated putting up. He was prepared to light the City on as good terms as were offered to anyone else.

The **Remembrancer:** But are you prepared to light the City on as good terms as any other company?

The **Witness** declined to answer the question. What he meant by saying that he dealt very tenderly with the Chelsea Company was that the Chelsea Company had already got certain statutory powers, and it would be unfair for another company to come in and ask for less powers. Therefore they consented to the proposal of Chelsea that they should put themselves in a more unfavourable position with regard to that parish than other places.

Cross-examined by Mr. A. C. Cripps, who represented the Metropolitan Company, the **Witness** said that it was his conviction that it was more economical to supply electricity from one large station that from a number of small generating stations as was proposed by the Metropolitan Company, one of the conveniences being the facility and cheapness of getting their coal supply.

Mr. Cripps (representing the Metropolitan Company): Are you aware that, as regards two of the stations proposed by the Metropolitan Company, they are riverside stations with the same conveniences that you have at Deptford?

Witness said he was aware that there was one there. He believed there was one at Waterloo Bridge—Greenmore Wharf was the name of the other. His experience was that in these central stations navigation coal had to be used, and the expense would be 20 per cent. more than that of the coal used at Deptford. He was aware that modern appliances abated the smoke nuisance. They had tried these appliances, but had failed with them, owing to the noise that they caused. They could not get rid of the noise though they might get rid of the smoke. He had never had the pleasure of being at the generating station at Whitehall, and he did not know the conditions under which the work was carried on there; but it was a small station capable of supplying only 5,000 lights simultaneously. (A voice: "13,000 lights.") It was also situated in the middle of property belonging to one person, and the only neighbour it had was a large hotel—the Hotel Métropole—on the opposite side of the way.

Mr. Cripps: Putting aside the question of the cost of coal, then, it comes to a question whether you can work without causing any noise or not?

Witness said it was to a great extent. He believed, too, that the saving that resulted from economy in supervision was considerable.

Mr. Shiress Will, Q.C., M.P., on behalf of the House-to-House Supply Company, asked how much capital had been spent on the works at Deptford.

The **Witness** replied that he could not tell. The company proposed to duplicate the machinery, so that they might be prepared to cope with any accident which might happen to one portion of it. The pressure at which it was proposed to distribute the current would be 2,400 volts. They would distribute it from as many centres as they had local authority to do so—possibly 18 centres, which was the number of authorities they had to deal with. The cost of laying the mains would be about 6d. a yard.

In further reply to Mr. Cripps, he said that it would be as easy to supply the Marylebone district as a place only 100 yards away from their distributing stations.

Mr. Loyd asked how the company proposed to allocate the light?

The **Witness** replied that they would give 10,000 lights to each district for which they sought powers, excluding the City proper, to which they were prepared to give 30,000 lights. They proposed to give an all-night supply and to be able to give a day supply if required. There was no more difficulty in satisfactorily supplying the current from Deptford than there was in supplying gas from Beckton. The leakage would certainly be larger in gas than in electricity. A distributing station differed from a generating one in this—that it required no moving machinery, there was no fuel burned, and consequently there was neither smoke nor vibration. By their system they did not store electricity. They would be in no worse position than a storage company supposing that a strike were to continue for more than 24 hours. At the Grosvenor Gallery they supplied at the present time about 33,000 lights. The Electric Lighting Act of 1882 had led to considerable delay in the development of electric lighting. They had made agreements with the various railway companies for wayleaves to bring their mains into London at different points.

Mr. S.Z. de Ferranti, chief electrical engineer to the London Electric Supply Corporation, was next examined by Mr. J. C. Graham. He deposed that the corporation commenced work at Deptford about a year ago by making considerable excavations over a space of about 200ft. square. They had put up buildings and chimneys sufficient for 24,000 h.p. They had now got the machinery for 6,000 h.p. complete, the remaining 18,000 h.p. being in course of erection. They had two sets of engines of 1,500 h.p. each, capable of generating electricity to supply 25,000 lamps. In addition to that they would have two engines of 5,000 h.p., so that their available h.p. would be 13,000, capable of generating 250,000 lights. He saw nothing remarkable in having such large engines, considering the size of those employed now in steamships. They did not intend to work their machinery up to more than 150,000 lamps, leaving a margin of 100,000. They were to lay six mains from Deptford to London, with concentric conductors—two to London Bridge, two to Cannon-street, two to Blackfriars, and two to Charing Cross. They would be carried on cast-iron brackets which were provided with indiarubber or porcelain supports, so as to ensure proper insulation. The mains were so arranged that they could be switched on to any of the engines at Deptford, so that in the

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event of one of them breaking down it could be easily replaced. The distributing stations would be supplied from those mains, and in order that there might be a total failure of light in London there must be a breakdown of all their mains and engines at the same time—a contingency highly improbable. The tension in the mains was to be 10,000 volts, and would be converted at their distributing stations into 2,400 volts by means of transformers. The supply from each distributing station would be a duplicate one, so that both sources of supply would have to fail before London was plunged into darkness. It was precisely the same system as was working at the Grosvenor Gallery with so much success, each distributing station being to all intents and purposes a small Grosvenor Gallery. A transformer served precisely the same purpose as a regulator for reducing the pressure of gas, steam, or water. The loss of pressure from the Deptford mains would be about ½ per cent. per mile of the energy sent, or 1 per cent. on the five miles. When the mains were in full working order with a pressure of 10,000 volts, nobody could be hurt by taking hold of them. They were perfectly insulated. The pressure at which they were to work was no element of public danger any more than the system adopted at the Grosvenor Gallery, where they had experienced no trouble whatever. There were great advantages in having their central station at Deptford—such as cheapness of land, and coal, and, besides, they would have sufficient storage space. They would have capacity for storing 30,000 or 40,000 tons of coal. Then they had all the advantages that arose from the concentration of their work, not to speak of the abundant supply of water which they would get by being on the banks of the Thames. At the Grosvenor Gallery they were very much troubled with fog. It came on so suddenly that it put an immense strain on the station. The fog did not envelop all the districts of London at one time, so that by having a large area to light they would not necessarily have to put the whole of their pressure on at once—that was to say, the City might be using its lamps when the West End did not require to do so. He had no personal experience of the electric light in America beyond what he read and heard, from which he gathered that the transformer system gave much satisfaction there. There were over 120 central stations in America upon that system.

Cross-examined by Mr. Moulton, Q.C. (representing the Chelsea Electric Supply Company), the **Witness** said that there were some towns in France where the system was adopted. Nancy had 10,000 lights running at the present time. They had also the transformer system at Milan and Vienna. At the Grosvenor Gallery they had no electrical difficulties which had not been thoroughly over come, and what difficulties they had had arose from want of space and their plant. The plant was not originally designed with a view to provide for extensions in their supply, so that they had been effected with very great difficulty. There was not, however, a trouble which they had experienced at the Grosvenor Gallery which would have to be dealt with at Deptford. He did not think their only advantage was in being on the river side. Other people had access to it as well. As to the matter of coal, he did not think that their machinery would require less than 200 tons a day to supply 100,000 lights. He could not tell the inspector what a system that employed storage would require. He was practically acquainted with only small storage installations. There had been no such large dynamo used before as they proposed to use at Deptford. It would be 20 times the size of that in use at the Grosvenor Gallery, and the pressure at which the current would pass along the mains would be four times as great as that hitherto used in London for ordinary purposes. Some of their mains were laid underground at the Grosvenor Gallery station. They were worked at a pressure of 2,400 volts. It did not appear to him that insulation was more easily attained by overhead wires. Underground mains, he thought, were adapted for a general supply.

The enquiry was then adjourned.

The enquiry was resumed on Friday morning.

Mr. S. Z. de Ferranti was recalled and cross-examined by Mr. Moulton. He said that his experience of electric lighting had not lasted for many years. From everything he knew the system which they proposed to adopt with regard to the jointing of their underground mains would not break down. The mains could be either curved or on expansion joints. Which was the more desirable system, time alone could tell. The Nancy system had different lamps, and had been supplied for a year and a half. His dynamos were started very nearly a year ago there. A current in the main, which would destroy the insulation, would certainly affect the main externally. His experience of a load of that kind of high tension, however, was that it did not affect it immediately. Safety fuses were set at a very small amount above the carrying capacity of the mains. His experience was that a partial leak could not occur to a concentric main. At Nancy they had had no fault in the insulation. What he meant by concentric mains was a stranded core, then insulation then wire stranded round that again. They proposed to connect with earth at the Deptford end, but to insulate along the line in order not to disturb telephone and telegraph wires. If any other point got to earth, there would be no leakage affecting the lighting system, but there would be a leakage to effect a disturbance. It would disturb the telephones. There would be practically no shock felt by touching those huge conductors. They had tested for the purposes of the underground railway to see whether the concentric mains supplying the current, and put to earth at one end, would give a shock, and they could not feel it. In transformers the pressure varied inappreciably, they found. The efficiency within the transformer itself varied, but he said it was not of considerable importance as regarded the supply from the station. They proposed to have a transformer in each house. He had heard that that practice was not allowed in America. He had heard that the regulations in America admitted a pressure of only 1,000 volts. He did not know that the insurance companies, who refused to allow transformers in a house, regarded them as a source o danger. At present they were laying their mains along the railway and their experience with concentric mains showed that there was no external effect when they were short-circuited. They had short-circuited them with 20,000 volts, and worked with two 50-horse transformers in series with a lead-covered table, which showed it more easily. Their present plant would be equivalent to probably a quarter million lights. In case of a breakdown the interval of time required to switch one dynamo on for another was inappreciable. The darkness occasioned thereby would be too short to be appreciated by the eye.

Cross-examined by Mr. Shiress Will, the **Witness** said that their whole system of lighting would depend on the current coming from Deptford.

Cross-examined by Mr. Lyttleton (on behalf of the Metropolitan Supply Company), **Witness** said that the chief difficulties they had experienced at the Grosvenor Gallery station arose from the peculiar nature of their position. He did not know what the rentals of their distributing stations would amount to. These would be placed in convenient situations—presumably in accessible cellars. Their object was to distribute a large force of electricity over an extensive area economically. He felt sure it could not be supplied so cheaply by any other process.

Cross-examined by Mr. Russell Griffiths on behalf of the City Remembrancer, **Witness** said he knew that the City street lamps burned 4,000 hours in the course of the year. In addition to the applications which Lord Crawford said he had received for 70,000 lights, there would be the street lighting. It was not necessary to have a transformer in each house. It might be so arranged that 20 or 30 houses could be lighted with one transformer. So also the street lamps could be arranged in series of 20 lamps.

In further reply to Mr. Loyd, he added that preparations were now being made for bringing the mains into London across the river at London Bridge, Cannon-street, Blackfriars Bridge, and Charing Cross, agreements having been made with the various railway companies for way-leave. He considered that the street lighting of the City was the reverse of important to the company. They would be better without it. It would be commercially better for them to confine themselves to private lighting. There would be no transformers in the streets, but in the cellars which they rented. As to the testing-boxes, they would be placed at the corners of the streets like Post Office letter-boxes. The number of these that would be required to a mile of mains would depend very much on the nature of the streets. He could not give an approximate figure.

Cross-examined by Mr. Wilkins, representing the Vestry of St. James', Westminster, **Witness** admitted that if the consumers in that parish depended exclusively on the company for their electric supply, they would be deprived altogether of it if the station at Deptford broke down. There would be a saving of about 10s. per ton in coal by having their station at Deptford; how much in wages he could not say. He did not anticipate that there would be a great deal of wear and tear of the mains by running them at a pressure of 10,000 volts. The whole of the current would be generated at Deptford according to present arrangements. They sought no monopoly of the area which they wished to supply.

In further reply to Mr. Graham, he said that no danger could arise to the public from the short-circuiting of the inner and outer conductor. Their object was simply to supply electricity, and allow consumers to use it for whatever purpose they chose. He did not regard their scheme in the nature of an experimental departure. Their large dynamos were divided in such a way as to make them form a number of small dynamos for all practical purposes, and they would be much less strained than their present ones. He thought it was a much greater step to go from an 800 h.p. engine to one of 1,500 h.p. than it was to go from the latter to 5,000 h.p. after what they had experienced. Everything had been carefully considered. The effect of putting more or less work on to their transformers would be a slight fall in efficiency, not so much, however, in putting it on as in taking it off. They were designed to do an average amount of work. He had never heard of any serious accident from transformers placed in private houses. They had not so much objection to their having many testing-boxes as to their having to pay for the ground on which they were placed. His calculation as to the quantity of coal that would be consumed was based on actual experience at the Grosvenor Gallery. He thought there was no difficulty in ensuring the safety of their mains from being crushed by vehicular traffic.

Mr. George Richard Strachan, surveyor to the Vestry of Chelsea, was next examined by Mr. Loyd, and deposed that the Vestry was in favour of admitting competing companies to their parish, believing, as he himself did, in the beneficial results from a public point of view of competition, and they had granted their consent to the London Electric Supply Corporation to go there.

Dr. John Ambrose Fleming, examined by Mr. Graham said he had visited the United States in 1885, and studied electric lighting there, especially the incandescent systems established by Edison. At that time the transformer system had not come much to the front, and there were no central stations on a large scale. Since then there had been an enormous extension of the transformer system both in the United States and in Europe. All reserve power was provided for by means of spare engines, boilers, and dynamos. There were upwards of 200 lighting stations in the United States dependent on these means of reserve force. There were, in a sense difficulties in insulating every current of high or low tension, but they were not insuperable. The higher the degree of E.M.F. the greater would be the precaution required to be taken, but there was no impossibility in doing it. His recollection of the City of New York was that about 100,000 lights would be used per square mile, including private houses, shops, and warehouses. The efficiency of a transformer would be affected if it were too heavily loaded. The scheme of the London Electric Supply Corporation was

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merely experimental in the sense that the Forth Bridge was—in point of size. In his opinion there was a greater economy of electrical energy by the use of transformers than there was by the use of secondary batteries.

Cross-examined by Mr. Russell Griffiths, the **Witness** said that he had seen an engine of about 600 h.p. employed, but the ones generally used in America were from 300 to 400 h.p. The direct system was chiefly adopted in America. The mains were laid in 20ft. lengths, there being 20 miles of them laid in New York. They were all connected with one central station. There was no sensible leakage from the joints. The electrical pressure in them was 100 to 200 volts, never in excess of the latter figure. He had tried experiments with a pressure of 10,000 volts on flexible and rigid conductors, but not on any system of mains. The loss of energy on the Edison system was very small.

Examined by Mr. Graham, **Witness** said that the question of leakage was merely one of care in the insulation. Joints were not necessarily a source of weakness if properly made.

Mr. Musgrave Heaphy, technical adviser to the Phœnix Fire Office, examined by Mr. Loyd, said that he had examined installations on the transformer system. He had heard of the proposal of the London Electric Supply Corporation to increase the voltage in their mains to 10,000, reducing it by means of transformers to 2,400 in the distributing mains. He had considered the question from an insurance point of view, and he did not think there would be the slightest danger if the work was performed according to the Phœnix Fire Insurance Office rules.

Cross-examined by Dr. Hunter, M.P., **Witness** said that the English mode of insurance was not conducted on the American principle. He had heard that American fire offices would not insure premises unless the transformers were situated outside the building which had to be lighted. But he spoke as a practical man, and could say that where an installation had been properly put up, he had never known a single instance of fire. There was no appreciable risk in having the transformers inside houses if the Phœnix Office rules were observed. It did not matter from an insurance point of view whether the voltage was 10,000 or 20,000.

Cross-examined by Mr. Russell Griffiths, **Witness** said he had seen the majority of installations in London under the transformer system. He thought it would be advisable to build in every house using the light a fire-proof chamber for the transformer. In the majority of instances it was already done. He had made this year an enormous number of inspections for insurance in London where installations on the high tension system were put up, and he had not known of an instance of fire occurring from them. The risk was very slight.

Major Charles B. Waller, manager of the London Electric Supply Corporation, examined by Mr. Graham, said that the company had received 82 applications for light from the City, 21 from the Strand district, 10 from St. Pancras, 40 from Marylebone, 40 from St. James's, 15 from Westminster, and 75 from various other parishes, making 277 in all. In addition to these, they had many hundreds of applications in the form of letters which were not registered. In the majority of cases the applicants were waiting to receive the current from the Deptford station when it was in proper order. Those applicants would want, in round figures, 50,000 lamps of 10 c.p. If they had a current for 100,000 lamps they could place the whole number in the city at once with private consumers, excluding the public lighting.

Cross-examined by Mr. Hunter, he said that they had a very large demand for lighting in the neighbourhood of Cadogan-square, not as the result of the energy of canvassers, but due to the requirements of the public. They had never had any system of canvassing. He had been manager of the corporation 18 months, and during that time he had no complaints about the failure of the supply of the light. They had not been always able to give as good a supply as they had wished. There had been very large extensions of their business during his management—principally by overhead wires.

In answer to Mr. Lyttleton, he added that they proposed to close the Grosvenor Gallery station as a generating centre as soon as the Deptford one was open.

Cross-examined by Mr. Russell Griffiths, **Witness** said that it was generally assumed for all practical purposes that London took one gas-light per head of the population. That was what the corporation which he represented went upon in estimating what strength of electric current would be required for lighting a given area. Eventually they would be prepared to supply the City with 300,000 lamps if they were wanted. They would endeavour to keep pace with the demand.

Cross-examined by Mr. Wilkins, he said that the company, where they were now supplying light in 99 cases out of 100 required a pole on a roof of a house for the purpose of carrying the cable and the right of user for the general system of their cables. They had had some customers who discontinued their system of lighting. A few were no doubt lured away by perhaps the better terms of other companies, while others preferred to go back to gas for the sake of economy. In some cases they discontinued to use it because they did not pay their bills. They had about a fourth of their customers on meters supplied by the firm of Messrs. Ferranti and Co.

Mr. Ferranti, recalled and cross-examined by Mr. Wilkins, said that the cost of bringing the electric current from Deptford, compared with the cost of the plant at Deptford, would be in the proportion of 7 to 100.

In reply to Mr. Cripps, he said he thought it would be desirable to have two companies supplying the same district, in which case he would suggest that both of them should lay their mains together so as not to break up the streets twice. The space required for electrical mains was not large. It would not be always an advantage to have their mains in close proximity to the houses. He did not think that anybody would lay a trunk main along the Strand, but merely the mains that were intended to supply the neighbourhood. They would be in a position to lay all the mains within three months of the granting of the provisional order.]

COMPANIES' MEETINGS.

ELECTRICAL POWER STORAGE COMPANY, LIMITED.

The eighth ordinary meeting of this Company was held on Wednesday, the 10th inst., at Winchester House, E.C., Sir Daniel Cooper, Bart., G.C.M.G. (chairman of the Company) presiding.

Mr. Holland Dell (secretary) having read the notice convening the meeting,

The **Chairman** said: I now propose to offer some remarks and explanations upon the report, and the figures in the statement of accounts where they seem to call for observation. During the past year there has been a gratifying increase of business. This increase is mainly made up of a great number of small orders for storage batteries, which are employed for the variety of purposes detailed at length in the Directors' report. By far the larger portion of the gross profit of £13,273. 15s. 3d. has been earned in the manufacturing branch of the business, as the firms and companies on the Continent who have agreed to manufacture Electrical Power Storage batteries, under royalty, have taken a longer time to complete their arrangements than was anticipated. There is an increase of £165. 5s. 9d. in the item of rates and taxes, owing to the payment of income-tax. We have not done so much advertising lately, so there is a diminution of £293. 6s. 8d. in that account. The shares allotted last year to the Managing Director had been charged against the reserve at par value. The Company has taken out what we believe to be valuable patents in the United Kingdom, and in several continental countries for improvements in details of arrangement in the Electric Power Storage accumulator, and also for distributing apparatus in connection therewith, and much time and thought has been given by Mr. Frank King, our chief engineer, and our technical staff to perfecting what is commonly known as the Electrical Power Storage system of distribution by storage batteries. On the other hand, law costs and patent fees account is less by £194. 2s. 3d., because we have had no professional fees to pay, and are for the present free from litigation. The amount allowed for doubtful debts has proved more than ample for the purpose, and there is a balance over, which we consider sufficient for this year. There has been, as mentioned in the report, some additional outlay, owing to the increase of business, on the plant and buildings at Millwall works, and further outlay will have to be made this year. The amount under the heading of "sundry creditors" is larger, but against this is the increase in sundry debtors' account, while the cash balance at the bankers is £3,000 more than it was last year. In the report is given a selection from a long list of new electric light installations in which Electric Power Storage batteries are used. Reference is also made to various scientific and technical institutions which have adopted accumulators, and I do not think I need here enumerate them. You will have noticed that Electric Power Storage batteries are now used for all kinds of purposes—train lighting, ship and yacht lighting, omnibus and carriage lighting, and for power in tramcars, electric launches, and again for surgical purposes. In short, their use is becoming general, as you will have gathered from the paragraphs which have appeared in many newspapers during the past year, and you may take it that, though the name of the Electric Power Storage Company has not always appeared, yet, in 99 cases out of 100, the batteries were the Electric Power Storage type. Among the latest interesting applications of batteries, I would mention the printing at the office of the *East Anglian Times*, at Ipswich, by power supplied by Electric Power Storage batteries, which are placed at the central lighting station of Messrs. Laurence, Paris and Scott, Limited, in that town, a description of which was sent to the shareholders with the report. I must now dwell for a moment on the subject of central station lighting, the importance of which to this Company cannot be overstated. The Company has applied for provisional orders for Paddington, St. Martin's, and the Strand districts, and an enquiry is now being carried on, under the instructions of the Board of Trade, upon questions which relate to the whole of the applications for provisional orders in the metropolis. I shall refrain from making any observations thereon, as the matter is still *sub judice*. I will now pass to the Chelsea Electricity Supply Company, which is supplying light in the parish of Chelsea. You may not be aware that this is the first company which has supplied electric light in London under the statutory powers of a provisional order. It has acquired these powers by Act of Parliament, Vic. 50, cap. 18. The Electric Power Storage Company, in conjunction with the Anglo-American Brush Company and the Callender Bitumen and Telegraph Company, took up the Chelsea Company last July, and contracted to furnish the necessary plant, and they have now carried it through to its present stage; and I feel confident that the combined efforts of the three companies, each in its own special line, will result in a model central station. The system of distribution is that of the Electrical Power Storage Company, by which the current is supplied from the main station to storage batteries placed in convenient sub-stations throughout the district to be supplied. We believe this system to be the best for such populous districts as Chelsea, and that the public will give the preference (when once they become acquainted with its essential features) to the only system in which a reservoir of light, in case of accident from any cause whatever, is provided. Our managing director, Mr. Courtenay, is a director of the Chelsea Company, having joined the board at our request. You will, perhaps, have read the pamphlet issued by the Electrical Accumulator Company of New York. I need only remark that judgment has now been given against the Julien Company for infringing the Faure patent, and therefore that company will be put under injunction. The trial of this suit has taken more than twelve months, and the investigation has been one of a most searching and exhaustive character. The shrewd advisers of the American company consider, as they state in the document referred to, that they had already got the control of the accumulator business in the States from their other patents, even without

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the Faure patent, and now they have this basic patent also declared valid, their position should be doubly assured. I beg to move the adoption of the report and accounts, and ask Mr. Sellon to second the resolution.

Mr. John Scudamore Sellon: Gentlemen, in seconding the resolution, I have little to add upon general points to the remarks of the Chairman, or to the matters dealt with in the report. It would, of course, have been gratifying, and doubtless for many reasons acceptable to all of us, and certainly more pleasant for the Directors, if we could have arrived at the conclusion to recommend a dividend. One large shareholder remarked to me, after the report had been published, that, if we had declared one, our shares would immediately have doubled in market value. This may be the case, although in view of what is before us, I see no reason why our shares should not quadruple in value, without our troubling ourselves about a dividend at present. The Directors are bound to consider the exigencies of the business they direct, and are not justified in diverting what they consider necessary for the protection of the internal interests of an undertaking simply in order to affect the external value of the shares. It has been a labour of years to build up this business, to overcome violent antagonism, and to establish the secondary battery upon a firm basis as an indispensable and reliable factor in electric lighting. This having been at last accomplished, and the first great start given, would it not be unjustifiable to do anything which might cripple us for a moment in grappling with the great extension of work which is before us? Instead of diminishing the resources at our command, we could with considerable profit employ further capital. In fact, every £1,000 in a growing business of this kind is of value, and I may say that, realising this, your Directors have not for, I think, fully two years taken out any of their well-earned fees. On former occasions I have somewhat exhaustively dealt with most of the technical questions in connection with this undertaking, and I have pointed out the wide and extensive range of work which lies before us. I need not, therefore, now detain you with any further remarks on such points, but, perhaps, you would permit me to say a few words on your position as owners of patents. The Chairman alluded to the recent important decision given in the courts of the United States in favour of the Faure patent, after one of the hardest patent fights on record. With the exception of one decision, sustainng one of the Thomson-Houston patents for an arc light regulation device, this is the only electrical apparatus patent pertaining to lighting or motor business, the litigation on which, in the courts of the United States, has terminated favourably for the patentee. The Faure patent is one of those which, as you know, is held by the Electrical Accumulator Company of America, a powerful corporation formed to work our patent rights in the United States, and in which we hold, I am glad to say, a very considerable interest The importance of the decision will be obvious to you when I explain that this patent entirely controls the use of active material supplied to the plates, and I assure you that no efficient, practical secondary battery can by any known means be made without such application. It is a fundamental and essential point of construction. I ought, perhaps, at the same time, to mention that the Swan patent, for simple perforation plates, came before the same court and was not upheld; but the decision did not arise from any invalidity of the invention itself but upon a matter of form, proof not having been put forward, I presume from some oversight, as to the earlier date of the English patent compared with that taken out in the United States. If considered necessary, this can doubtless be put right, and this priority—it is incontestably capable of proof—can be established; but, in any case, the matter is of no great importance. Though the patent is an important one in itself, the manufacture of plates, as carried on by all the infringers, comes within the claims, not only of the Faure patent, which has been upheld, but of several other of the Electrical Power Storage group of patents which are held by the Accumulator Company. Of course, neither here, nor in other countries where we hold patents, is the Swan patent in any way affected by this temporary decision of the United States court. I would take this opportunity of explaining to you that you possess in the Electric Power Storage group of patents some 40, all more or less important, fully covering each and every point and detail of our business, and, so far as is within my knowledge, not one single outside patent exists which would be of use to us in our manufacture, or which would, as the Americans call it, be worth a red cent. to us. Several of the patents are, as in the case of the Faure, covering or controlling patents, in the sense that no economical and efficient secondary battery can be constructed without infringing them. Every perfect plate now made embodies the principles of no less than four of these patents in its manufacture, and in the completed cell the details come into play. Then, as several of these patents are of recent date comparatively with our basic patents, you have the great advantage of prolongation of the term of your practical monopoly of manufacturing storage batteries, because, naturally, the most perfect battery is the one which will always command the market. You will, therefore, feel justified in considering your position in this important and indispensable branch of the electrical industry to be not only unique, but unassailable. I would only further remark that as time passes and experience is gained the more absolute is the confirmation of the views put forward by myself and a few others some years ago, but doubted and criticised at the time by many electricians, even of eminence, that it is to the employment of the secondary battery that we must look for the attainment of the most reliable, safe economical, and generally acceptable system of electric lighting; and I confidently anticipate that one of the results of the important investigation now being carried on under the commission of the Board of Trade sitting at Westminster Town Hall—which is literally absorbing the interest of the electrical world of England—will be to enable, not only electricians, but the general public, more vividly to realise the solid and paramount advantages of the storage system which this Company advocates and controls.

Mr. E. C. Schomberg expressed his dissatisfaction at no dividend being declared, but the Directors proposing to carry forward a balance of net profit to the amount of £8,372, he urged that a portion of this ought to be divided among the shareholders.

Mr. J. W. Barclay, M.P., commended the policy of the Directors, thinking it would be a great misfortune to starve the Company. He congratulated the Board on the position the Company had attained, which was due to the Directors' pluck and energy, and thought it gave promise of very substantial and, he might say, brilliant results in the future. He believed the commission now sitting would give a great impetus to electric lighting, that extensive orders from foreign countries would bring in a large revenue, and that the value of this Company's interest in the American company would greatly develop.

Mr. John Irving Courtenay (managing director) answered some questions put, and said he hoped that in the current year the Directors would lay before the shareholders a scheme for raising further capital, taking into account the debentures which would fall due in May of next year. He stated that the holding of this Company was nominally of the par value, £140,000, and he believed that company had the control of the business over the whole of America.

The motion was carried unanimously.

Mr. Barclay proposed the re-election of Sir Daniel Cooper and Mr. Courtenay as directors, and the motion was seconded by **Surgeon-Major De Tatham,** and carried unanimously.

On the motion of **Mr. Grindle,** seconded by **Mr. Schomberg,** Messrs. Deloitte, Dever, Griffiths, and Co. were re-elected auditors, and the meeting concluded with a vote of thanks to the Chairman, which was moved by **Mr. Barclay,** and seconded by **Mr. Schomberg.**

EASTERN EXTENSION, AUSTRALASIA, AND CHINA TELEGRAPH COMPANY, LIMITED.

The half yearly meeting of this Company was held on Wednesday, at Winchester House, Sir John Pender presiding.

The **Chairman,** in moving the adoption of the report and accounts, said the gross receipts for the half-year amounted to £238,854, against £232,660 for the corresponding period of 1887, showing an increase of £6,194. The amount would have been considerably greater but for the loss of subsidy, £2,700, and probably £5 000 of additional traffic, resulting from the unfortunate interruption of the Australian section referred to at the last meeting; in addition to which there had been during the half-year the heavy loss of £6,947 on exchange in consequence of the increased depreciation of the silver currency. The working expenses amounted to £71,519 against £69,570, being an increase of £1,949, mainly due to the cost of the repairs of cables having been heavier than in 1887. Comparing the figures for the whole year with those of 1887, the results were as follows: Gross receipts in 1888 £478,730, against £451,861, showing an increase of £26,919, or over 1 per cent. on the share capital; working expenses, £140,911, against £145,811, showing a decrease of £4,900. An interim dividend of 1¼ per cent. having been paid for the past half-year, it was now proposed to pay another dividend of like amount, making, with the interim dividend for the first half-year, a total of 5 per cent. for the year. It was also proposed to distribute a bonus of 3s. per share, making a total of 6½ per cent. for the year. The balance of £66,101 had been carried forward to the reserve fund, which now stood at £690,454; in addition to which £15,401 had been charged against revenue for the cost of completing the renewal of the cable from Singapore to Saigon, and £4,292 for the rebuilding of the staff quarters at Cape St. James. The net result of the past year's working was that the reserve fund had been increased by £70,359, the cost of renewals of the Singapore-Saigon and Java-Australian cables, and of the rebuilding of the staff quarters at St. James, amounting together to £38,879, had been paid out of the revenue, and 6½ per cent. distributed to the shareholders. Since the close of the year, the laying of the new cable between Java and Western Australia, to which reference was made at the last meeting, had been successfully completed, the cost of that extension, the object of which was to strengthen their system and minimise risk of interruption, being £130,000. In concluding, Sir John remarked that everything was going on satisfactorily, that only one of the Company's cables was at that moment interrupted, and that in consequence of their having duplicate, and in some cases triplicate, cables, when a break occurred there was no cause for alarm.

The motion (which included the declaration of a dividend) having been seconded by **Viscount Monck,** was adopted.

The retiring Directors were re-elected, and a vote of thanks was given to the Board.

MONTE VIDEAN AND BRAZILIAN TELEGRAPH COMPANY.

An ordinary general meeting of this Company was held at the offices, 2, Tokenhouse-buildings, E.C., on Tuesday last, under the presidency of the Chairman of the Company (Mr. Charles Cameron, M.P.).

The **Chairman,** having moved that the Directors' report and statement of accounts should be approved and adopted, said the report this year was more favourable than had been the case on any previous occasion, owing to the improvement in the revenue of the Western Brazilian Company. The Monte Videan revenue depended upon the earnings of this company. Mr. Ogle's report stated that he had examined the books of the Company and found them correct, but that the Western and Brazilian had objected to an inspection of their accounts, and, therefore, he had not been enabled to verify their takings. This difficulty arose under an original agreement, under which the Platino Company had a right of inspection of the Western Brazilian, and, consequently, their auditor had access to the accounts, and saw that they were paid a proper percentage of the receipts. For

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many years their Company had access to the books of the Western Brazilian, but after a while they objected, and they found they had no powers to enforce an inspection.

Lieut.-Colonel Macaulay seconded the adoption of the report, which was carried *nem. con.*

A dividend of 3s. 6d. per share on the preference shares of the Company, absorbing £1,454. 19s., was declared.

The Auditor of the Company was re-elected.

NEW COMPANIES REGISTERED.

Northampton Electric Light and Power Company, Limited.—Registered by Deacon and Co., 4, St. Mary-axe, E.C., with a capital of £20,000 in shares of £1 each. The object is to carry on a general electric motor and lighting business. The first subscribers are:

	Shares.
S. L. Seckham, Beacon-place, Lichfield	100
D. J. Morgan, 1, St. Helens-place, E.C.	100
R. Cleaver, 71, St. Giles-street, Northampton	100
P. Phipps, Collingtree Grange, Northampton	100
H. E. Randall, The Elms, Billing-road, Northampton	100
H. Manfield, Cliftonville, Northampton	100
F. H. Thornton, Daventry, Northampton	100
M. H. Holding, 10, Cyril-street, Northampton	100
R. E. Crompton, Mansion House-buildings, E.C.	100
H. Gibson, 4, St. Mary-axe, E.C.	100

The number of Directors shall not be less than three nor more than seven. The following persons shall be the first Directors—viz., S. L. Seckham, D. J. Morgan, R. Cleaver, H. E. Randall, H. Manfield, F. H. Thornton, and R. E. Crompton. The remuneration of Directors shall be determined in general meeting.

CITY NOTES.

Great Northern Telegraph Company.—The receipts for the month of March amounted to £21,000.

Brazilian Submarine Telegraph Company.—The receipts for the week ending March 29 amounted to £5,351.

Eastern Telegraph Company.—The receipts for March were £55,987, as against £54,376 for the same period of 1888, or an increase of £1,611.

Eastern Extension Telegraph Company.—This Company's traffic receipts for the month of March were £42,896, as against £39,670 for the same period of 1883.

Western and Brazilian Telegraph Company.—The receipts for the past week, after deducting the fifth of the gross earnings payable to the London Platino-Brazilian Telegraph Company, were £3,993.

Glasgow.—We are notified that Mr. Rankin Kennedy has ceased to manage the Woodside Electric Works. The proprietorship remains the same as formerly, and the business will now be carried on under the name of the Woodside Electric Company.

West India and Panama Telegraph Company, Limited.—At the approaching meeting of this Company, the Directors will recommend a dividend of 12s. per share, on account of arrears of dividend on the first preference shares, and an addition of £1,000 to reserve, carrying forward £1,154.

Indo-European Telegraph Company, Limited.—After transferring £10,000 to the reserve fund, the Directors of the Indo-European Telegraph Company, Limited, recommend a balance dividend of 17s. 6d. per share, together with a bonus of £1 per share, making a total distribution of 10 per cent. for the year ended December, 1888.

PROVISIONAL PATENTS, 1889.

April 1.

5515. **Improvements in telegraph instruments.** Arthur William Cox and Walker and Co., London and South-Western Railway Station, Winchester.

5563. **Improvements in electric batteries.** Henry Harris Lake, 45, Southampton-buildings, London. (Lacombe and Co., France.)

April 2.

5612. **Improvements relating to the distribution of electric currents, and to apparatus therefor.** Henry Harris Lake, 45, Southampton-buildings, London. (Edwin Wilbur Rice, junr., United States.) (Complete specification.)

5615. **Improvements in the generation of electricity on railway trains.** Illius Augustus Timmis, 2, Great George-street, Westminster.

5621. **Improvements in and relating to electric induction-coils or transformers.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) (Complete specification.)

5640. **Improvements in or relating to electric railway signals.** Alfred Julius Boult, 323, High Holborn, Middlesex. (William H. Waddell, United States.) (Complete specification.)

5656. **A novel arrangement for conducting an electric current through the nose.** Herrman Welcker, 11, Wellington-street, Strand, London.

April 3.

5676. **Improvements in electric bells.** David Reid and James Kean, 154, St. Vincent-street, Glasgow.

5738. **Improvements in and connected with insulators for electric light and other wires.** Arthur Wellington Fitch, 4, South-street, Finsbury, London. (Richard Oliver Gardner Drummond, South Africa.)

5730. **An improved combined ampere and volt meter.** Samuel Joy and William Henry Joy, 37, Chancery-lane, London.

April 4.

5768. **Improvements in wooden casings for electrical conductors.** Walker George de Forgés Garland, 191, Fleet-street, London.

5774. **Electric lamps.** Robert Percy Sellon and Arnold John Spiller, 112, Belvedere-road, Lambeth.

April 5.

5816. **Improvements in electrical accumulator or secondary batteries.** William Edward Langdon, The Telegraph Department, Midland Railway, Derby.

5832. **Improvements in electricity meters of the pendulum class, parts of such improvements being applicable to other kinds of electricity meters.** George Hookham, 7 and 8, New Bartholomew-street, Birmingham.

5839. **Improvements in dynamo-electric machines.** Thomas Henry Allum, Guy Carey Fricker, and John Richard Bainton, 39, Montserrat-road, Putney.

5844. **Improvements in protecting telegraph, telephone, electric lighting, and other installations and instruments from damage by lightning or other high-tension electric currents, and in apparatus therefor.** Oliver Joseph Lodge, 6, Lord-street, Liverpool.

5867. **Improvements in connection with switches for telephone circuits.** Alfred Graham, 47, Lincoln's-inn-fields, London.

April 6.

5888. **Improvements in methods of measuring electric resistance.** Alexander Pelham Trotter, 2, Victoria-mansions, Westminster.

5894. **Conveying electricity or communicating with light vessels by electricity.** William Edward Blackburne, 22, Canning-street, Liverpool.

5904. **Improved means and apparatus for electrically communicating between trains and fixed points or stations.** William Willort Popplewell, 17 and 18, Southampton-buildings, Middlesex. (Felix Lefrancois, Eugene Manborgne, and Oscar Boin, France.)

5912. **Improvements in systems of suspending electric conductors.** Charles Joseph Van Depoele, 77, Chancery-lane, London. (Complete specification.) (Date applied for under Section 103 of the Patents Act, 1883, 10th September, 1888, being date of application in the United States.)

5913. **Improvements in devices for establishing electrical contact in electric railways.** Charles Joseph Van Depoele, 77, Chancery-lane, London. (Complete specification.) (Date applied for under Section 103 of the Patents Act, 1883, 7th September, 1888, being date of application in the United States.)

SPECIFICATIONS PUBLISHED.

1884.

9982. **Electric currents.** Abel (Zipernowski and another). (Second edition.) 8d.

1886.

2783. **Electromotors.** Jarman. (Second edition.) 8d.

1888.

3968. **Electric arc lamps.** King. 8d.

6928. **Electric switches.** Andersen and Tafe. 8d.

7901. **Electromagnets.** Horne. 4d.

17222. **Electric arc lamps, &c.** Paget. 8d.

1889.

375. **Electric glow lamps.** Bernstein. 6d.

2748. **Telephonic switching apparatus.** Bennett. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price. Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¼
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	17¾
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply	5	4½
......	...	Swan United	3½	2½
12 July	12/0	Telegraph Construction	12	42
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	16½

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NOTES.

Royal Yachts.—*Truth* states that the "Osborne" is to be refitted with electric light.

Amiens.—Other installations are shortly to be put down in this town. Four of five thousand lamps are, it is said, subscribed for. The cathedral will be lit shortly.

Multiple Electric Lock.—A superintendent of an asylum has invented a lock by which all doors can be opened by the touch of a button, to be used in case of fire.

Institution of Electrical Engineers.—The next paper will be read on Thursday next, the 25th April, at 8 p.m., by Prof. Oliver Lodge, F.R.S., "On Lightning Conductors."

Railway Lighting.—The train on the Penarth branch of the Taff Vale Railway, recently lighted by electricity, has 50 12-c.p. Edison-Swan lamps, run off a dynamo driven by the axle.

Utilising Niagara.—A Bill has been introduced in the New York Legislature authorising the Niagara Electric Hydraulic Company to erect a plant at the falls, on the plan devised by Mr. Hamilton.

British Association.—The offices of the British Association at Newcastle are now on the ground floor of the Literary and Philosophical Society, Library-place. The honorary secretaries are Prof. S. H. Merivale and Dr. Bedson.

Honiton.—At the Honiton Town Council last week, it was decided to refer to the General Purposes Committee an application from Mr. H. J. Materface for leave to lay overhead wires, with a view of introducing the electric light into the borough.

Melbourne Exhibition.—Messrs. W. F. Dennis and Co. inform us that Messrs. Felten and Guilleaume (for whom they are sole English agents) have been awarded a First-Class Order of Merit in the electrical section of the Melbourne Exhibition.

A Prize for Inventors.—The Committee of the Parisian Press have had placed to their credit by M. Osiris a sum of 100,000f. for award as a prize to the author of the most remarkable work of art, industry, or public utility in the great Universal Exhibition.

Electric Goods Traffic.—Several of the street railways of America now run "freight cars" for goods traffic as well as their passenger cars. These have proved a great convenience to the inhabitants and a source of considerable income to the tramway company.

New Periodical.—We have been favoured with the first number of *El Progreso*, a weekly journal of politics, science, art, and commerce. It is printed in the Spanish language, and dates from Buenos Ayres, in the Argentine Republic. We wish it every success.

Electric Sewage.—The question of the electric treatment of sewage came before the Wolverhampton Town Council last week, but Alderman Gibbons thought that this system was not applicable to Wolverhampton owing to the sewage there being charged with waste acids.

Faraday Lecture.—The Faraday Lecture of the Chemical Society will be delivered on June 4th, by Prof. Mendeleef, in the theatre of the Royal Institution. The fellows of the society will entertain the Faraday Lecturer at a dinner at the Holborn Restaurant on the following evening.

Italy.—*L'Elettricità* announces that the public lighting in Milan is to be extended to the following thoroughfares: Via Durini-Verrière, S. Pietro in Gersate, Francesco Sponza, Corro di Porta Vittoria, as well as to the Via Meraviglia Maria alla Porta and the Corra Magenta.

Berlin.—The machines in the Mauerstrasse station, Berlin, are said to give satisfaction. They supply 3,000 incandescents. The difference of potential at the terminals is 120 volts, and the speed 730 revolutions per minute. Other dynamos of a capacity of 10,000 lamps are in course of construction.

Reuter's Company.—The report of Reuter's Telegrams Company shows net profits for the year ended December amounted to £1,222. 8s. 6d. The directors have transferred £3,448. 15s. 2d. from the reserve fund, and declared a dividend of 5 per cent. for the year, carrying forward a balance of £446. 1s. 7d.

Electric Water Indicator.—The Maidstone Water Company have accepted the tender of Mr. George Jennings, Lambeth, for a second set of patent electrical apparatus for indicating, in the engine-house at East Farleigh, the level of water in the reservoir of the Kent County Asylum, Barming, including lines between the two points.

Edison Exhibit.—The American journals announce that Edison will send to the Paris Exhibition a monster model of an incandescent lamp, 40ft. high, of which the bulb will be formed of 20,000 small lamps. This will, it is said, be flanked by representations of the French and American flags done in coloured incandescent lamps.

Hammersmith.—At the Hammersmith Vestry, the Law and Parliamentary Committee reported with reference to the application of the West Middlesex Lighting Company for the supply of the electric light to certain streets in the parish, recommending that under certain conditions the Vestry grant the application. The recommendation was adopted.

Reading.—At the last meeting of the Reading Town Council, applications from Mr. Yeatman (on behalf of Messrs. Laing, Wharton, and Down) to fix a further electric lamp at King's-road corner, and from Mr. Wyles (local manager of the South of England Telephone Company), to erect additional wires across the public thoroughfares, were granted.

Effect of Conduits on Price.—In tendering for the public lighting of the streets of New York, the electric light companies have doubled their rates where subways have to be used, on the ground that they will have to pay rent to the subway company. The price tendered for light from poles is 35c. per night; but with wires in the subways the cost is to be from 65c. to 68c. for the same hours.

A Note for Landowners and County Councils. With reference to the electric tramway in Richmond, Virginia, now celebrated throughout the civilised world, the Richmond (Va.) *State* says: We have now nearly 20 miles of track. The building of the electric line has given an impetus to suburban improvements which will eventually add much to the beauty of our suburbs and their taxable values.

Overhead Wires in New York.—The Mayor of New York has ordered the removal of all overhead wires along Broadway from Fourteenth to Thirty-fourth

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street, the telegraph companies not having complied with the regulation to place their wires underground within the specified time. The work of removal commenced on Tuesday, a number of wires and poles in various localities having been pulled down.

The Telephone in France.—It is stated that on the 26th instant, the Chamber of Deputies will proceed to nominate the commission to report upon the reorganisation of the French telephone system. The members of the commission, who, by the way, are in favour of the proposal of the Government, will be MM. Saint Prix, Munier, Sarrien, Bernier, Goirand, Steenackers, Gobron, Million, Bizarelli, Lalande, and Georges Cochery.

Electric Theodolite.—The Italian papers report that an "electric theodolite" has been set up at Maddalena to defend the island of Caprera, communicating with a gun battery behind a high hill, and so arranged that the defenders can ascertain the position of invading ships, and fire over the hill at them, but cannot be fired upon. The arrangement appears to consist of a small camera obscura on the hill, connected by electrical contacts with the gun battery in the valley.

Electric Date and Time Stamp Company.—We are requested to state that there is no connection between this company and the Time Stamp Company, against whom a winding-up order was granted by Mr. Justice North on Saturday last. We understand that the ingenious instrument invented by Mr. C. A. Randall, which we recently described, is now being made in large quantities for the Electric Date and Time Stamp Company, and orders for these in large numbers are already in hand.

Electric Light for Vestrymen.—The Works Committee, at the meeting of the St. Martin-in-the-Fields Vestry, on April 4, reported on the tenders for the supply of fittings for the purpose of supplying electricity to the Vestry-room and lighting it. The Metropolitan Electric Supply Company and the London Electric Supply Company both tendered, and the Vestry accepted the tender of the first company to supply six 16 candle lamps for £12. 12s., and supply a current for £12 per annum. The report was adopted.

Electric Light Currents in the Telephone Wires.—On Thursday last the subscribers to the Chatham Telephone Company were considerably startled and alarmed by the continual ringing of the bells connected with the telephones. It was found impossible to stop the ringing and other noises which came from the instruments, and, on an enquiry being made, it was found that in altering one of the telephone wires it had been placed slightly in contact with the electric light wires, and this caused the unusual disturbances.

An Electric Light Cake.—At the recent celebration of Mr. Edison's forty-second birthday, the servants employed in his house and outbuildings, not to be outdone by the employés of the laboratory, presented him with a birthday cake of immense size and novel construction. It was about 2ft. in diameter and 12in. high. It bore the inscription: "Thomas A. Edison, 1889," in coloured greenish-white frostwork, and around its edges were 42 tiny incandescent electric lights, supplied from a battery placed in a cavity in the centre of the cake.

Lighting of a Public Laundry.—A public steam laundry has just been opened at Hertford for the town and district, replete with every appliance and convenience for carrying on a very extensive business. It has been fitted by Messrs. Bradford and Co. with washing machinery, with their most recent apparatus. The laundry is lighted by incandescent lamps, worked by a vertical engine of four h.p. nominal. The work, with entrance lodge and stables, has been carried out by a local builder, Mr. H. Norris, from designs by Mr. William White, F.S.A.

St. Louis Exposition.—In September next the International Exhibition at St. Louis, U.S., will open again, and exhibits of the latest improvements in electrical machinery have been promised from America, England, Germany, Russia, Spain, Belgium, and France. The whole northern nave will be electrical. An electric railway, with cars on different systems, will run continually. A coal-mine lighted by electricity will be worked by electrical coal-drills; mining stamps driven by motors, and other of the latest applications of electric power, will be shown.

A Long Span.—The new span of telephone wire crossing Dartmouth Harbour just erected by the Western Counties and South Wales Telephone Company, under the direction of the general manager, Mr. H. F. Lewis, is, as far as we know, the longest span of wire in England. The wire is 800 yards span (nearly half a mile), and is 200ft. above water-level. A very fine light wire of silicium-bronze (No. 17 gauge) has been used, and it has already stood two very severe gales satisfactorily. The strain on the wire is 58lb., and the weight of wire to each span is 24lb.

The Paris Exhibition.—The temporary installation, for the purpose of enabling the exhibition works to be proceeded with at night, which is being put down in the Champ-de-Mars by the Edison Company, consists of 45 750-c.p. arc lamps, distributed over the Palais des Beaux-Arts et des Arts Libéraux, the Dôme Central, the gallery of machines, and various other parts of the building. The motive power is divided into two groups, each group including a portable engine by MM. Weyher and Richemond, and a dynamo giving 75 volts and 223 amperes.

Effect of Legislative Telephone Rates.—A Bill to regulate the rate of charge for telephone was recently introduced by the Legislature for Kansas City. The effect has been that the Telephone Company made a bold move for freedom. It cut down its staff of linemen to ten, notified that all contracts will be cancelled as they fall in, and, if the Bill passes, they intend to remove all instruments from the city. As the company control 1,900 patents, and no other telephone company could work without them, the result of the attempt to reduce the rates is not encouraging.

Electric Yacht.—Yachting is as favourite a sport on the East Coast of America amongst wealthy merchants and others as on our own coasts, and over there electricity is to be applied in the service of these pleasure ships. An electric yacht is to be added to the New Haven Yacht Club, and accumulators will be used to drive a motor, so that the yacht can run in calm weather as well as when breezes blow. The bottom of the vessel is lined with lead to prevent damage from the acid, and the other cells themselves will serve as ballast. There to be 25 cells and a 6 h.p. motor, connected directly to the propeller. The motor will not be used when there is a good wind.

Tender for Lighting Galatz.—A despatch has been received at the Foreign Office from Her Majesty's Consul-General at Galatz reporting that the Municipality of that

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town are prepared to receive tenders for the lighting of the town either by gas or electric light, and that the specifications of their requirements can be seen at the Municipal Offices at Galatz. The tenders must be sent in by the 25th May, O.S. (June 6), and must be accompanied by a deposit of 25,000f. in cash or Government securities. Applications in respect of this matter should be made in French or German.

Telephones for Divine Service.—With the consent of the pastor and deacons of the Congregational Church at Tunbridge Wells, the South of England Telephone Company have been experimenting with their instruments with a view to perfecting the transmission of a religious service to distant and scattered parts of a locality. Telephonic communication having been established within the building, the service on Sunday was listened to by about a dozen people gathered at various points in the town. One or two doctors and chemists' assistants on duty at their respective establishments joined with the congregation in the service, as did also an invalid lady who has been bedridden for a long time.

Mr. F. J. Sprague.—The American journals announce that Mr. Frank J. Sprague, of the Sprague Electric Railway and Motor Company, will probably visit Europe during the summer. Mr. Sprague is one of the busiest men in the States just now, but in view of his disposal of the patent rights in England (with which the recent visit of Mr. J. B. Verity is said not to be unconnected), we may expect to see Mr. Sprague himself to look after pushing the motor trade here. English makers of motors had better wake up, and try to push their wares practically and in an active commercial spirit in this vast field lying open at their feet, or the wind will be taken out of their sails by the States in motors as, heretofore, in arc lamps.

Profits from Electricity.—The following comparative statement of the virtues of horse and electric traction is from a letter from the president of the Davenport (U.S.) Electric Railway, in the *Street Railway Journal*. The figures are for similar periods in 1887 and 1888. The road is a small one, equipped with four 14ft. Sprague cars, each with two 7½-h p. motors, and one 10ft. car; the gradient is 7½ per cent. The figures speak for themselves.

	1887. Horses.		1888. Electricity.		Increase Per Cent.	
	Gross.	Net.	Gross.	Net.	Gross.	Net.
Sept.	$1,374	$474	$1,997	$997	48%	110%
Oct.	1,232	302	1,903	1,121	57 „	270 „
Nov.	1,131	231	1,886	986	66 „	320 „
Dec.	1,283	353	2,022	1,122	59 „	220 „

Detroit Storage Cars.—The accumulator cars at Detroit are approaching perfection. The cars now run the whole day with one charge. A trial run, consisting of 11 round trips with the usual passengers, was perfectly successful, and a speed of 11 miles an hour was easily attained. The cars are fitted with 84 cells of the Detroit storage battery made by the Woodward Electrical Company. The manager is satisfied that with these 300 ampere cells round regular trips of 100 miles can be run with one charge, and the battery can be recharged at 300 amperes, or even more if necessary, in six hours. A most important item is that the manufacturing company guarantee to keep the battery in repair at 10 per cent. per annum during the full life of their patents—namely, 17 years.

Electric Lighting in Paris.—At a meeting held on the 3rd inst., the Municipal Council of Paris approved a scheme for the lighting, from the 1st of May to the 1st of November, 1889, of the principal boulevards and the Rue Royale, from the Place de la Republique to the Place de la Concorde. The lighting will be carried out in conformity with the agreement made between the Société Popp, the Edison Company, and the Société Anonyme de le transport de la Force par L'électricité. At the same meeting the following gentlemen were appointed technical members of the Commission of the Municipal Lighting Station: MM. Mascart, Potier, Hospitalier, and two delegates nominated by the Syndicat professionel des Electriciens, and the Chambre Syndicale des ouvriers électriciens.

The Electric Omnibus.—Before the London County Council last week, the committee reported that they had had before them a letter from the Commissioner of Metropolitan Police, stating that an omnibus propelled by electricity occasionally passed through some of the streets of London within the hours prohibited for locomotives, such prohibited hours being specified in by-laws made by the late Metropolitan Board in the year 1879, under the powers given by the 31st section of the Highways and Locomotive Act, 1878. The Commissioner of Police desired to be informed whether the Council was of opinion that any action should be taken. The committee recommended that the Commissioner of Police be informed that, in the opinion of the Council, there is no necessity, at all events at present, for any action to be taken with respect to the vehicle referred to. The recommendation was agreed to.

The Electric Duel.—The Westinghouse Company having taken no notice of Mr. Harold P. Brown's challenge to an electric duel to prove comparative safety, this gentleman returns to the charge with respect to economy, and challenges the Westinghouse Company to a trial at the electrical testing bureau of the Johns Hopkins University, to test the accuracy of their statement that they give 50 per cent. more light per pound of coal than is given by any direct system of lighting. The plant of the losing company to be presented to the university. Mr. Brown will use a Thomson-Houston direct current plant, and if the Westinghouse prove 50 or even 25 per cent. the better, Mr. Brown will pay all expenses. In event of refusal, Mr. Brown announces his intention to buy a Westinghouse plant and get it installed by former Westinghouse employés for the test.

Water Gas.—In a note on thermo-batteries in this journal for June 29th last year (p. 605), Mr. J. W. Swan alluded to the probability of extended use of Mr. A. Wilson's "water gas," a gas obtained from water by blowing a mixture of steam and air through a column of incandescent carbon. We notice that Mr. Wilson, who has for some years been manufacturing and using his water gas at his house and office at Stafford, has disposed of his patent rights to the British Water Gas Syndicate, Limited, and will leave Stafford to become their general manager and chief engineer at Leeds. Mr. Wilson is also engaged in the manufacture of "producer gas," in which coal is transformed into gas, reinforced by the decomposed water in the above manner. By this process a ton of coal produces 150,000 cubic feet, or fifteen times the volume of ordinary lighting gas.

Electric Search Lights.—Colonel Burton, R.E., Superintending Engineer, 1st Circle, at Madras, has sent in an indent to the Director-General of Stores in England for three electric search lights for use in Madras. Each apparatus is to work independently of the other two, and

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is to be provided with three or four branch reflectors, for use at some little distance, probably 150 to 300 yards from the engines and dynamos. The lights are to be of the pattern used on shore during the sham night attack made by Her Majesty's ships in Portsmouth, on the occasion of Her Majesty's review of the Fleet in July, 1887. They will be used by the military authorities, and the Admiralty will be consulted as to the special kind considered most suitable. The places at which the lights will be erected are to be selected hereafter. The Public Works Department will erect the necessary masonry works, etc.

The Liverpool Tramways.—We announced some weeks ago that the directors of the Liverpool Tramways Company were desirous of substituting mechanical haulage in place of horses on their line. We are now informed that after the most careful consideration of all the various systems of mechanical traction, Sir David Radcliffe has advised his board that the system of "self-contained" accumulator cars which he recently inspected at the Electric Traction Company's Barking-road installation is the best adapted for tramway work, and the Liverpool company have entered into arrangement with the Electric Traction Company and the North Metropolitan Tramway Company to supply them at once with an experimental car, together with the necessary electrical equipment, similar to those which are now working on the North Metropolitan section between Canning Town and Green Gate, Barking-road.

Electric Light at the Suez Canal.—It is satisfactory to observe, says the *Daily News*, that there is one part of the world where the new illuminant is in very active development. We refer to the Suez Canal. The use of the electric light, which was at first restricted to vessels carrying the mails, has, since the new regulations, which came into operation two years ago, been allowed to all ships under certain conditions. The result has been that last year a total number of 1,611 steamers navigated the Canal with electric light as compared with only 395 in 1887. The numbers seem to increase regularly, for whereas in January, 1888, there were only 86 ships so lighted, there were in December as many as 178. The average time of transit by steamers traversing the Canal with electric light is stated to be 22 hours 26 minutes. The shortest time by a steamer with electric light for night navigation was 14 hours 55 minutes in 1888, as compared with 15 hours 5 minutes in 1887.

Electric Lighting of Tunnels.—We have already alluded to the successful lighting of "the Hoosac tunnel's bore" with thousands of incandescent lamps, to the great comfort and convenience of both passengers and employés. The tunnel of the New York Central Railroad underneath Fourth-avenue will soon be lighted in the same way, with strings of incandescent lamps at the height of the seats of the carriages. The annoyance caused by the blackness of some of the suburban tunnels in the daytime to City men travelling up and down the line is a source of real loss to the railway companies, many persons refusing to live in suburbs served by a railway having a long black tunnel, and whose carriages are often not lighted in the daytime. The Blackheath and Sydenham Hill tunnels are examples, and it might be worth consideration by railway directors if similar lighting to that undertaken in America might not prove beneficial to both passengers and themselves, for what conduces to comfort in travelling conduces to their own profits

Electric Lighting in France.—Dieulefit and Valréas, two small towns in the departments de la Drôme and Vaucluse, have a central lighting station which is not without interest. The two localities have a station common to them both at Béconne (Drôme), a distance of eight kilometres from Dieulefit and 15 kilometres from Valréas. Water power is employed, the turbines giving 50 effective horse-power. Three Zipernowski alternate-current dynamos of 24,000 watts each (2,000 volts and 12 amperes) are used. One serves the Dieulefit circuit and one the Valréas circuit. The third is in reserve. The difference of potential at the terminals of the primary circuit of the transformers is 1,750 volts, with 95 volts at the lamp terminals. The localities are connected with the dynamos by two overhead cables. That to Valréas is of silicium-bronze of 3·3mm. section and a length of 13,300m. That to Dieulefit is 3,700m. long, and 3·2mm. diameter. The lamps are Edison-Swan 16 c.p., and the price is put at about two centimes per lamp hour. The installation has been carried out by MM. Lombard-Gerin, of Lyons.

Electricity and the Gas Companies.—There seems every reason to believe that the gas companies are fully alive to the importance of taking Time by the forelock. One by one the continental companies are losing faith in the unsavoury element in which they deal, and, following in the footsteps of their American brethren, are girding on the armour of the enemy. At Montauban the gas people are applying for powers to establish a central station for lighting by electricity. At Angers, at Florence, at Perpignan, they are doing the same thing. We congratulate them, not upon their early appreciation of the superiority of electric over gas light, but upon the wisdom which leads them to even a tardy acknowledgment of defeat. They have made much capital out of *the occasional* failure of a badly arranged electrical plant. There was an outcry at Barnet, which gas echoes multiplied and made much of. We hear, however, that Madrid indulged in a howl of the most pronounced description, when, on one occasion, at 7 p.m., the city was plunged in darkness, and the *gas* manifested itself solely in the not-unfrequent form of smell.

Electric Snow-Ploughs.—Some of the Sprague motor lines are now being fitted with snow-ploughs for clearing the tracks in winter. These are driven by powerful electric motors, and it is estimated that these electrical ploughs will clear the tracks quicker than an ordinary plough drawn by a dozen horses, so that no snow, however deep, will be able to stop the running of the cars. In this connection it may be worth while to mention that a new form of screw rotary snow-plough has been introduced by Mr. Orange Bull, of Orangeville, Canada, the inventor of the rotary snow-plough, now often used on American railways, where the drifts are sometimes enormous, mounted in front of and driven by a special locomotive engine. In the latest form, illustrated in *Engineering News* (New York), for March 30, the plough is a huge taper knife-wheel, 9ft. in diameter, provided with four to eight knives, and revolving at 200 to 300 revolutions a minute. The knife-wheel is in reality a huge gimlet, forcing its nose into the snow, and pushing it backward, and then discharging it at a high velocity. The direction of discharge is regulated by the openings in the top of the closed-in case.

In the year 2000.—For an ideal representation of life in the next century nothing so powerful and interesting has been written, so far as we know, in its realisation of

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the probable set of the evolution of social forces and the application of science to the uses of life, as the little shilling book, "Looking Backward," by Edward Bellamy (Reeves, 185, Fleet-street), in which a member of the present civilisation of Boston, in the year 1887, is mesmerised and accidently left in a trance in an underground fireproof sleeping-room. He awakes in the year 2000, and relates his experiences of both periods of life. The tendency of consolidations, trusts, and syndicates has grown into a vast and beautiful system of co-operative life; towns and habits of life are transformed, evolving into beauteous and satisfactory models. Electricity, of course, plays a great part in this rejuvenated paradise: one of the greatest differences being the absence of chimneys and smoky atmosphere by the adoption of electric fires and electric power. Selections of classical music are laid on to each house by telephone. Tubes for rapid transit of men and materials are laid in all towns and communicate with the villages, and the dreams of electrical engineers generally are carried out. Innumerable benefits on all hands accrue to society at large; and believers in the progress of human society (than whom none surpass electrical engineers in general) may be interested in following the prophecy of the clever author, in spite of the seemingly Utopian ideas which it embodies. The book has already achieved seventeen editions, a fair proof of its popularity.

The Central Station at Havre.—We have already announced that MM. Ch. Mildé fils et Cie have obtained the necessary authority to establish a central lighting station at Havre. The following details may be of interest: subscribers are to engage to take the light for a period of five years, with a minimum of 750 hours' lighting per annum. The price per 100 watts hour is fixed at 12 centimes, but an alternative arrangement is 5f. per carcel and 7f. for two carcels for incandescents extinguished at 10 p.m.; 70f. for 35 to 50 carcel arcs and 150f. for 120 to 150 carcel arcs extinguished at the same hour. Should the lamps be required to burn until midnight, the charges are 7f. 50c., 12f., 130f., and 275f. respectively. The fittings are supplied by the company, and burnt-out lamps will be replaced free of charge; broken glow lamps are to be paid for by the subscribers at the rate of 4f. each. These tariffs are reduced one-third in the case of the vessels belonging to the Municipality, and one-half for public lighting. During the continuance of the concession the company are to pay (1) a tax of 100f. per kilometre or fraction of a kilometre of underground mains, and (2) an abatement equal to 5 per cent. of the gross proceeds of the station. If the generating power is located in Havre, this percentage will be raised to 6 per cent. The company are to commence the work of construction within eight months, and to be ready for lighting within two years under penalty of forfeiture of the concession. The authorities reserve the right to take over the works after a period of ten years.

Accumulator Patents.—The decision of the American Courts has been given by Judge Cox on the accumulator patents, and invalidates several of the principal clauses while upholding others, and generally illustrates the inadvisability of claiming too much. The Court, while acknowledging Mr. Faure as an inventor of undoubted genius, considers itself forced to limit his invention to the application of an active material in the specific form of a "paint, paste, or cement," leaving any broader idea of the application of an active material generally out of consideration. Again, the fourth claim of Mr. Faure's patent, in which the grouping of the plates in a series of cells with a non-porous partition between them is claimed, is held to be invalid as it shows no invention, and does not come under the head of a new combination of old and well-known materials, but is held to be a combination which would occur to anyone versed in the art. In the case of the two Swan patents, the judge has decided that they are both invalid. The first of these relating to the application of the active material to a perforated plate is decided to be void on account of an anticipation due to Prof. Eaton, of Brooklyn, whose testimony went to show that he had perforated lead plates for that purpose before the issuance of Swan's patent. And again, the second patent of Swan for the arrangement of such perforations in regular order is held by the judge to constitute no invention, for the reason that it would be a most likely thing for anyone constructing such plates to so perforate them. The result of this decision illustrates the need for continuous and rigorous search for anticipations, and the absolute necessity of careful and accurate claims on the part of patentees.

Folkestone.—A stormy meeting was held by the Folkestone Town Council on Wednesday last week with reference to the introduction of the electric light. After much discussion as to whether members interested in the gas interest were to be allowed to vote (during which one of the aldermen left the room after "playfully tapping Mr. Logan on the head with his stick, in response to a humorous remark by that gentleman"), the Town Clerk read the report of the committee, which stated that, in their opinion, the terms of the provisional agreement between the committee and Messrs. Crompton and Co., electrical engineers, Chelmsford, were fair and reasonable. The lamps were to be arc lamps of 1,200 c.p., 43 in number, and the light was to be supplied by duplicate sets of plant, so that if one should fail half the district only would be in darkness. Private consumers were to be supplied at certain rates, and the wires were to be overhead or underground according to the dictum of the lord of the manor. They were, moreover, to be lighted half an hour after sunset and to be extinguished one hour before sunrise; and a penalty of 4d. per lamp per hour was to be paid by the company in the event of the light not serving. The terms were £24 per lamp per annum, paid quarterly. The contract was to be entered into for five years, from August 10 of this year. The cost of the electric lighting would be £1,032, against £1,034 charged for gas lighting, the former sum including everything. Mr. Thomson then moved the adoption of the report in the terms of the resolution as read by the town clerk, saying that the electric light would yield 51,600 c.p., as against 4,312 of gas. They had made every arrangement in the event of a failure, and, in fact, it amounted to this: that whereas the Corporation would only have to pay £24 per arc light, if they failed the amount recovered would be £62 per arc light. He thought, therefore, that they had safeguarded the town in every possible way; they had shown them that the cost was practically the same as that of gas, but that was not the only advantage of the introduction of the electric light. The number of hours the arc lamps would be lighted was 300 in excess of the gas lamps. Mr. Salter moved an amendment, which was supported by the Mayor, that the matter be adjourned, and the contract printed and circulated. The amendment, however, was lost, and the resolution was carried by one vote, six voting for, and five against, the resolution.

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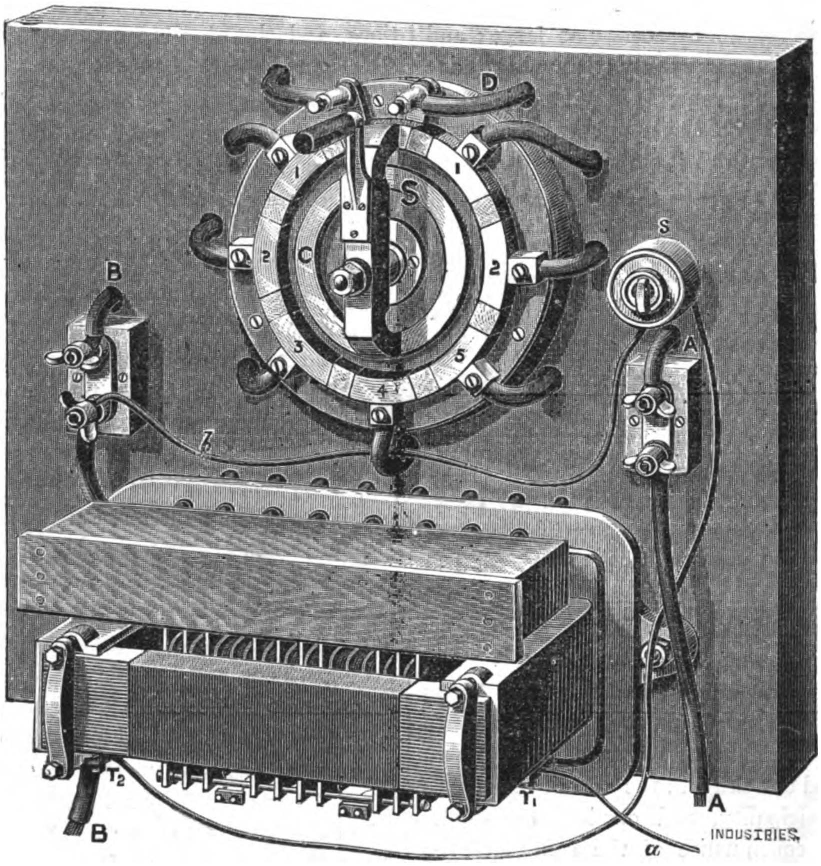
THE KAPP REGULATING TRANSFORMER.

Amongst the various advantages possessed by the system of alternating current distribution, is that of facility of regulation. One of the most important conditions in any system of central station lighting is that of keeping the pressure at the points of consumption as nearly as possible constant. In the direct current system, equality of pressure over the area supplied from a central station by feeders is generally obtained by the insertion of rheostats into these feeders; but this plan, besides entailing a considerable amount of watchfulness and labour on the part of the attendant, has the disadvantage of wasting energy. With an alternating current supply on the feeder system, the problem can be solved in a far more simple and less wasteful manner. Constant pressure at the feeding points, at all times and for all loads, can in this case be obtained by the insertion of a small transformer into each feeder, which raises the pressure at the station end of the feeder by the exact amount which is lost on the way in consequence of the ohmic multiple contact switch the upper part of the board. In this particular case it was desired to have means for either raising or lowering the pressure in the lamp circuit, and the secondary coil of the transformer has therefore been divided into seven sections, five of which are traversed by the lighting current in one direction, and are used for raising the pressure, whilst the remaining two are traversed in the opposite direction, and are used for lowering the pressure. The switch has accordingly seven contacts. When the handle is in the position shown in the diagram, the whole of the secondary coil is cut out, and the pressure supplied to the lamps is that given by the secondary coil of the main transformer, which serves this installation. If the switch-handle be moved to the right over the contact marked I, the current in the lamp circuit is caused to flow through one of the opposing sections of the secondary coil, and the available pressure at the lamps is reduced by 2 volts. If the switch-handle be further moved to the right over contact 2, the second section is brought into circuit, and the E.M.F. is reduced by 4 volts. On the other hand,



resistance of the feeder. The primary coil of the regulating transformer is connected with the terminals of the dynamo, and the secondary coil is sub-divided into a number of sections connected with a multiple contact switch. The current flowing to the feeder is led by means of this switch through one, two, or more of the sections of the secondary coil, and receives there an additional E.M.F. proportional to the number of sections inserted. The regulating transformer is so proportioned that, when the whole of its secondary coil is inserted, the increase of pressure is just sufficient to make up for the loss due to the ohmic resistance of the feeder. If the current flowing out is below the maximum, the switch is set to some intermediate point, so that in all cases the pressure at the distant feeding end is kept constant. This principle of regulation, which has been devised by Mr. Gisbert Kapp, primarily with a view to its application in central station work, is also suitable for regulating the pressure on the lamp circuit in private installations; and we illustrate above one of these regulating transformers, as fitted to the electric light installation at the town house of Sir David Salomons, Bart., which is supplied with current from the Grosvenor Gallery. The whole apparatus is placed on a board, and fixed against the wall, the transformer occupying the lower part, and the if the switch-handle be moved to the left, those sections of the secondary coil in which the E.M.F. is additive are successively brought into circuit, each step adding 2 volts to the available pressure at the lamps, so that by moving the switch-handle round to the contact marked 5, an increase of 10 volts over the pressure given by the main transformer is obtained. The connections are as follows: The service leads from the main transformer are brought to two terminals, to which the main lamp circuit is connected. Into one branch is inserted the regulating transformer, connection being made with the cables A and P. One terminal, T_1, of the primary coil of the regulating transformer is connected with one of the main terminals of the supply circuit, and the other terminal, T_2, is connected by means of the switch, *s*, and wire, *b*, with the cable P, coming from the other main terminal. The switch, *s*, is inserted so that the primary can be cut off if the instrument is not required. The cable P is connected by a fuse and lead, B, with the inner contact, C, of the multiple contact switch, S, and the cable A is similarly connected with the middle or zero contact of the switch by the lead, D. The other contacts of the switch are connected with the different sections of the secondary coil in the manner already explained. The advantage of this

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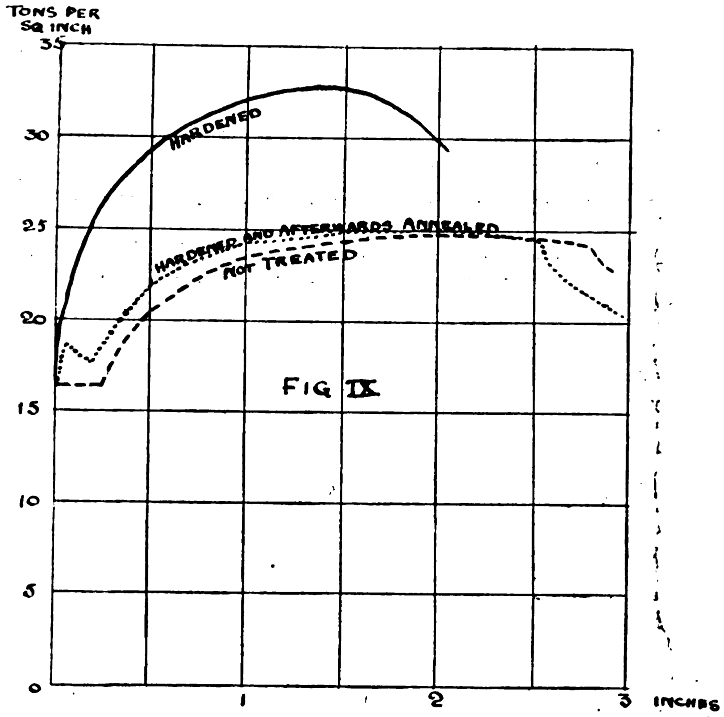
regulating apparatus is that without appreciable loss of energy, and by merely setting the switch to one or other of the contacts, the brilliancy of the lamps throughout the whole house can be regulated, whilst the regulating power is the same whether only a few lamps or the whole of the lamps in the house are alight. A rheostat or a choking coil could be used to lower (though not raise) the available pressure, but the effect would in either case be influenced by the number of lamps in use at any time. With the apparatus above described, the increase or diminution of pressure is, however, quite independent of the number of lamps in use, and the consumer is able to burn his lamps with either a higher or lower voltage than that supplied from the central station. The regulating transformer above illustrated has been made by Messrs. Johnson and Phillips, Charlton.—*Industries.*

PECULIARITIES OBSERVED IN TESTING MATERIALS.*

BY W. CLELAND, B.SC.

(Continued from page 300.)

This third period, which Tresca calls the period of fluidity, is first started by some point of weakness where greater than when the test is slow, so that the metal should flow very rapidly; but, owing to the great internal friction of solid bodies, the flow is hindered, the load is run up, and the metal breaks prematurely. Rapid testing, then, should give higher breaking results. Contrary to common projudice, the elongation under rapid testing is increased. It has always been held that when a specimen was broken suddenly the strain was very small, or even nothing at all. But some experiments made by Colonel Maitland at Woolwich have dispelled such erroneous ideas. He took different specimens of the same kind of steel—steel which, in an unhardened condition, stood 26 tons per square inch and gave an elongation of 27 per cent. on a length of 2in. The ends of one of his specimens were screwed into two blocks which slid on guides. This was allowed to fall, and after falling for some distance the top block was arrested by stops, and the specimen broke by the momentum of the lower block. The ultimate elongation in this case was 47 per cent. His other experiment consisted in screwing the specimen into plugs which fitted a tube. The space between the specimen and the tube was filled with gunpowder and guncotton. This was exploded, with the result that the plugs were sent out in opposite directions, and the specimen broken. The ultimate elongation was from 47 to 62 per cent. Very little or no local contraction took place; the extension was general. The explanation of this is probably due to what was mentioned above.†



the metal contracts, forming a smaller sectional area, and thus giving a greater unital stress. This gives rise to a difference of pressure, and the flow is quite comparable with that of fluids. Now, if by any means we can prevent contraction taking place, we will increase the apparent strength of the steel. In an experiment made to determine this, two specimens were taken from the same bar. One had the ordinary form, while the other was V shaped at the narrow portion, thus:

The diameter at the bottom of the groove was the same as that of the body of the ordinary specimen, and the result was that the former gave way with 30·5 tons per square inch, and the latter with 24·6 tons per square inch. If the bar tested was of Lowmoor iron, it was found that the section, instead of being fibrous in appearance, was partly crystalline, nearly 50 per cent. in the former, but a very small percentage in the latter. When steel was tested the fracture, which in the ordinary specimen was of a fine crystalline nature, became coarsely crystalline when the V specimen was tested.

Time, again, is an important element in testing. We can see how this is by going back to the period of "fluidity." Suppose the load applied at a rapid rate, and that local contraction has set in, the difference of pressure will be greater than when the test is slow, so that the metal should flow very rapidly; but, owing to the great internal friction of solid bodies, the flow is hindered, the load is run up, and the metal breaks prematurely.

I have already mentioned the point known as the elastic limit, or the point where the proportionality between stress and strain ceases; but this point is by no means immutable. For one test, and with the material in a certain condition, the point is quite definite, but if we go past the elastic limit in a test, and then relieve the specimen of the load, we would find by repeating the test that the elastic limit was raised. When we test the strength of steel wire, and an ordinary specimen of steel, we perceive a marked difference. The latter is very much weaker. This is due to the amount of work done on the wire, and to show that this is really the case, two specimens were taken from the crankshaft of the U.S. despatch-boat "Dolphin," one from the centre,

* Paper read before the Physical Society, Glasgow.

† Besides this experiment of Colonel Maitland's we have those by Mr. Bottomley (see article, "Elasticity," in *Encyclopædia Britannica*). Eight specimens of soft iron wire were tested, by applying a gradually increasing stress at intervals of 10 minutes. These broke with loads from 43½lb. to 46lb., and elongations varying from 17 to 22 per cent. Another specimen had 43lb. left hanging on it for 24 hours, and then broken, as before, with loads applied at intervals of 25 minutes. This broke with 49¼lb. and 15 per cent. elongation. Another had a load of 43lb. left on it for 3½ days, and broke with a load of 51¼lb. and elongated 14·4 per cent. Loading a bar, first with 40lb., and then gradually increasing the load over a period of two months, broke it with 57¼lb.

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and the other from the surface of the shaft (The shaft had given way during the trial trip). The following were the results:

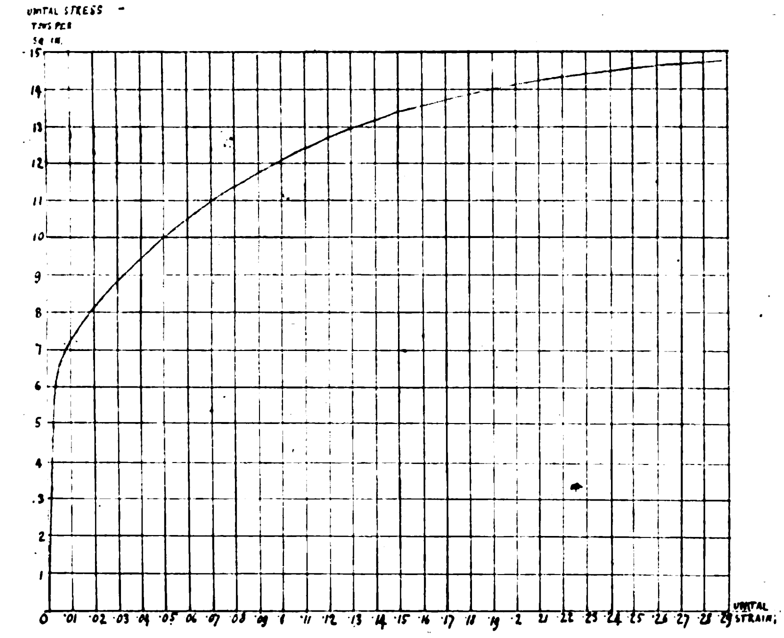
—	Elastic limit tons per square inch.	Tenacity tons per square inch.	Elongation per cent.
From centre of shaft	15·2	24·1	2
" surface "	14·3	35·7	18

THE TRANSMISSION OF POWER BY ELECTRICITY.*

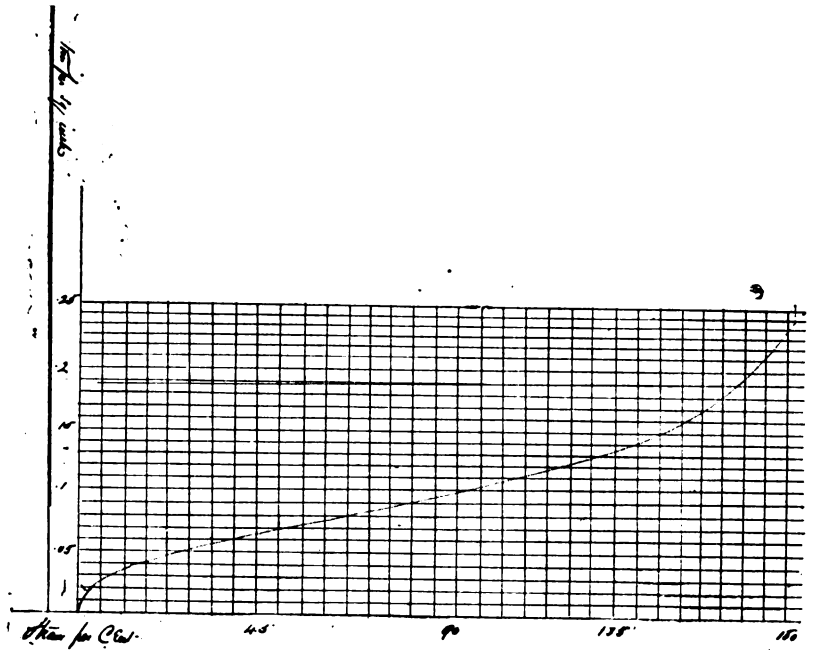
BY FRANK J. SPRAGUE.

(*Continued from page 293.*)

Let me give a practical illustration. Suppose we have a motor, the efficiency of which is 90 per cent. at 400 volts E.M.F., and when developing 10 h.p., and that we wish to transmit this 10 h.p. 5,000ft. from a station, and elect to lose about 9 per cent. on the line.



Autographic Test of Copper Wire. Dec. 3, 1888. Length tested = 24·38in. Diam. = ·021in. Area = ·000 35in. Speed = 1lb. per 48 secs.



Autographic Test of Indiarubber. Dec. 6, 1888. Thickness = ·15in. Breadth = ·083in. Area = ·0125 sq. in. Length = 1·73 sq. in. Load of 1lb. = 80lb. per sq. in. = ·036 tons per sq. in. Extension of 1in. = 13·7 per cent.

The difference is very much marked. We have also Sir William Fairbairn's experiments on the effect of cold rolling:

Material.	Tensile strength tons per square inch.	Elongation in 10in. per cent.
Rough rolled bar 1¼ diameter in ordinary state...	26·0	20·3
The same turned down to 1in. diameter in lathe ...	26·7	22·4
Bar, cold, rolled to 1in. in diameter	38·4	8·0

(*To be continued.*)

Our initial E.M.F. will be 440 volts, and we would have

$$C\,M = \frac{15{,}666 \times 10 \times 5{,}000}{400 \times 40 \times \cdot 90} = 54{,}396,$$

which is about equal to a No. 4 B.W.G.

Again, suppose we wish to transmit 5 h.p. over a distance of one mile on a complete metallic circuit of 45,000cm. allowing 5 per cent. increase of length for sag, and no leakage. Suppose further, that the initial line potential be 300 volts, and that we wish to have 250 volts at the motor terminals, it is required to find the commercial efficiency which the motor must have.

* A lecture delivered before the Franklin Institute, November 12, 1888.

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Transposing our formula, we have,

$$a = \frac{15{,}666\, n\, l}{E\, v\, C\, M}$$

and substituting,

$$a = \frac{15{,}666 \times 5 \times 5{,}544}{250 \times 50 \times 45{,}000} = 76\%$$

This formula is useful in determining what we cannot as well as what we can do. For example, if we made the condition 10 h.p., all others remaining the same, the commercial efficiency of the motor would have come out 152 per cent., a most excellent machine indeed, and yet it is precisely this absurd thing that people practically say they will do in many of the statements which are made in relation to this subject. No science admits of more easy determination of conditions by plain and simple laws, and none brooks less violation of them.

In considering the transmission of power, some very curious and valuable facts may be demonstrated by a formula for determining the minimum cost of plant, where the amount of power at the generating station is practically not limited, and where there is no line loss from leakage, the line loss being measured simply by the fall in potential.

The cost of a plant of this character can be divided into five parts—that of the motors, the conductors, the line erection, the dynamos, and the power plant, whether water or steam. I will assume that the cost of the dynamos and motors is the same per h.p. or other unit, no matter what the E.M.F. used. While this is not strictly true, for all practical purposes, with large units, and speaking from the commercial standpoint, it can be so assumed. This being the case, for any given power the cost of the motor is a constant, independent of the potential used. With any given motor potential, the greater the loss on the line, the less the cost of the conductors, but the greater the cost of the generators. On the other hand, the less the loss on the line, the greater its cost, but the less the cost of the generating plant. It follows, then, that the least cost to the contractor is determined when the variation in the cost of the generator is equal to that in the cost of the line, and it is to a consideration of this fact that I wish to call your attention:

We have the formula

$$C\,M = \frac{1{,}492\, n\, m\, l}{E\, v\, a}.$$

Let d equal weight of one mil-foot of copper. Then the weight per foot of the copper of our conductor would be

$$\frac{1{,}492\, n\, m\, l\, d}{E\, v\, a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

and the total weight for $2\,l$ would be

$$\frac{2{,}984\, n\, m\, l^2\, d}{E\, v\, a} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

If b is the cost in cents per pound of copper (the cost of insulation being added to cost of copper), we have for the cost of the wire in the line

$$\frac{2{,}984\, n\, m\, l^2\, d\, b}{E\, v\, a} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

It is to be noted here that this cost b must be expressed so much per pound of copper. It may be that we have a line covered by an insulation of such character that for every dollar's worth of copper there may be 3dols. or 4dols. worth of insulation. For example, suppose that a 1/0 B. W. G. wire be used, covered with an insulation that should make it cost, say, 150dols. a 1,000ft. The actual weight of copper in the line would be only 350lb., which, at 150dols. market price, would make the wire cost 43 cents per pound of copper. It is this cost, plus the cost of freight and handling, which must be used as the value of b.

Let E equal the E.M.F. at the terminals of the motor; e, the motor E.M.F.; v, the fall of potential on the line; β, the commercial efficiency of the dynamo; E″, the E.M.F. of the generator; and n the number of h.p. developed by the motor. Then we have evidently

$$\frac{e}{E''}$$

as the ratio of the watt capacity of the motor and generator;

$$\frac{n}{a}$$

the h.p. of electrical energy delivered at the motor terminals;

$$\frac{E+v}{E} \times \frac{n}{a}$$

the h.p. of electrical energy delivered to the line, and

$$\frac{E+v}{E} \times \frac{n}{a} \times \frac{1}{\beta}$$

that delivered to the generator.

I think it advisable to make use of the term h.p. and commercial efficiency, for it is partly from the commercial aspect I wish to look at the problem, and it is the side which in business we must confront.

Let us further make K equal the cost in cents of the generators per h.p. required to drive them, and L the similar cost per h.p. of the steam or water plant, all of course erected in place—that is, with the cost of freight, handling, insurance, and erection added to the factory or shipping cost. Then the cost per h.p. of the generating plant complete would be:

$$\frac{E+v}{E\, a\, \beta}\, n\, (K + L) \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

If M is the cost of motor per horse-power developed similarly erected in place, the cost of the receiving plant would be n M.

We now have one element which is somewhat indeterminate, and is dependent chiefly upon distance and local conditions, and that is the cost of pole and line erection; and we will call this P.

Summing up our cost, we have the general expressions for the cost per horse-power delivered:

$$C = \frac{E+v}{E\, a\, \beta}\,(K+L) + \frac{2{,}984\, m\, l^2\, d\, b}{E\, v\, a} + M + \frac{P}{n}. \quad (7)$$

It is evident that this is variable, and since the costs of the motor and the line erection are arbitrary, the variation is narrowed down to the cost of the generating plant and the material in the line. It is here apparent, as already pointed out, that if we diminish the cost of the line by increasing the fall of potential, we must at the same time increase the cost of the generating plant, and, on the other hand, that if the loss on the line is reduced, its cost will increase, while that of the generating plant will diminish.

Differentiating with v as the variable, we have

$$\frac{dc}{dv} = \frac{K+L}{E\, a\, \beta} - \frac{2{,}984\, m\, l^2\, d\, b}{E\, a\, v^2} \quad . \quad . \quad . \quad . \quad (8)$$

or equating to zero

$$\frac{K+L}{\beta} = \frac{2{,}984\, m\, l^2\, d\, b}{v^2} \quad . \quad . \quad . \quad . \quad . \quad (9)$$

which is the condition of least cost.

From (9) we have

$$v = 54{\cdot}6\, l \sqrt{\frac{m\, d\, b\, \beta}{K+L}}. \quad . \quad . \quad . \quad . \quad (10)$$

That is, with fixed conditions of cost and efficiency of appatus, the number of volts fall to get the minimum cost of plant is a function of the distance alone, and is independent of the E.M.F. used at the motor, a somewhat startling conclusion.

Substituting the equivalent value given by equation (9) in (7), we now have for the equation of least cost

$$C = \frac{E+v}{E\, a\, \beta}\,(K+L) + \frac{v}{E\, a\, \beta}\,(K+L) + M + \frac{P}{n}. \quad . \quad (11)$$

The first element representing the cost of the generating plant, and the second the cost of the wire per the horse-power developed by the motor. The cost of the wire is given as a ratio of the cost per horse-power of the generating plant. From this equation we have the relation:

$$\frac{\text{Cost of wire}}{\text{Cost of generating plant}} = \frac{v}{E+v}. \quad . \quad . \quad (12)$$

This is not, however, in a very useful form, and since the commercial efficiency is that with which we are concerned, we will introduce a term, designating it λ.

We have for the h.p. delivered to the generator

$$\frac{E+v}{E\, a\, \beta}\, n,$$

and n that taken out of the motor; hence we have,

$$\lambda = \frac{E\, a\, \beta}{E+v}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

or

$$v = \frac{a\beta - \lambda}{\lambda}\, E \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

Substituting the value of v in equation (11), we have a new form of the cost equation as follows:

$$C = \frac{K+L}{\lambda} + \frac{a\beta - \lambda}{a\beta\lambda}\,(K+L) + M + \frac{P}{n} \quad . \quad . \quad (15)$$

a still simpler formula. We also have the relation

$$\frac{\text{Cost of wire}}{\text{Cost of generating plant}} = \frac{a\beta - \lambda}{a\beta} \quad . \quad . \quad . \quad (16)$$

That is, with any fixed couple and commercial efficiency, the cost of the wire should bear a definite and fixed ratio to the cost of the generating plant.

But the query arises at once—is this so, no matter what the cost of the copper? And the answer is an affirmative one, and why this is so will soon be apparent.

(To be continued.)

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THE

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NOTICE.

With this number is given a Steel Engraving of the Grand Hotel at Paris. Hundreds of English and American visitors will be in Paris during the Exhibition Season this year, and a very large number will undoubtedly patronise this Hotel. The Artist has placed the trees more for effect than from nature, we should imagine, from our knowledge of the spot, otherwise he has succeeded in producing a pleasing effect.

THE CITY.

"All things come to him who waits." So says the proverb, while another proverb tells us that "while the grass grows the steed starves." In other words, different conditions of things have their appropriate proverbs. Micawber waited, and in his case something did turn up. Electric light engineers have waited, and worked, for the City authorities to acquire that right frame of mind to view the general lighting of the City by electricity as a necessity. Step by step the question has been fought, prejudices have been overcome, ignorancies enlightened, till the victory has been so far won that tenders are out for the City lighting. As regards this tender, it has been in the hands of those desirous of tendering sufficiently long for them to have become thoroughly conversant with its requirements, and no doubt it will be largely used in future as forming a basis upon which to build other specifications ; hence we have, for the benefit of those readers who have not an original copy, given the specification in full in our columns. The only change made in the wording of the specification will be found in the second clause, sub-sections 1, 2, and 3, where "as marked" is given instead of "as coloured," the original plan accompanying the specification having the districts differently coloured, a proceeding obviously impossible in a newspaper.

With regard to the specification, considered as a specification, we must insist upon the fact that its framers thoroughly understand its imperfections. It has not been drafted with a view of giving a perfect specification to the world, but simply and solely with a view to obtain what they want for City lighting. Neither destructive nor constructive criticisms are wanted, and if any man or firm feels aggrieved that the wording is not such as they would prefer, their best plan is to pocket their grievances and tender clearly and plainly upon the lines laid down in the specification. There is a good deal of latitude left to the contractor, the one obvious feature being that the authorities require lighting that shall be certain and sufficient. It is evident, too, that niggardliness in the question of cost is not to stand in the way; for the specification practically admits that a nett profit of 10 per cent. upon the capital embarked is not too much to be expected. After that return is reached provision is made for the consumer as well as the supplier to benefit. We direct attention to these matters, because there exists far too great a tendency in some quarters to specify the lines upon which it is desired to tender, rather than to tender upon the lines specified by the purchaser.

The work to be carried out under this specification is by far the largest that has been designed in this or any other country, excepting, perhaps, the Deptford installation for the London Electric Com-

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pany, for whoever undertakes the supply of either district must make provision for general private lighting as well as general street lighting. The two will go hand-in-hand, with the additional provision for the distribution of power. There are about half-a-dozen firms, or rather there are only about half-a-dozen men who can carry out this lighting satisfactorily. Just as there are drawing-room soldiers, so there are drawing-room electrical engineers, highly ornamental, no doubt, but of little use in practice. It may at once be surmised that the ranks of the drawing-room, or rather schoolbook, engineer will furnish the critics unable to find any good thing coming from the City authorities. The latter, as well as the successful contractors, must be prepared to have all their plans pooh-poohed, and an infinity of suggestions put forward as to what ought and what ought not to be done. Interference has done enough harm heretofore, that would-be critics should take the advice of a celebrated writer upon the preservation of the teeth, who entitled his pamphlet "Shut your Mouth." The City authorities are keen enough business men to employ competent advisers, and if they act upon the advice given by competent men, insisting upon good work, and a just provision for emergencies, they cannot go far wrong. The advisers will not think for one moment of suggesting the tender being given to a set of company promoters, whose object is to float a company and clear out rather than embark their own capital, if they have any, in any legitimate work—they will rather incline to give the work to those who have had the most experience, and who have a reputation to lose rather than one to gain.

The half-dozen firms who are capable of being entrusted and of carrying out successfully work of this magnitude will, no doubt, consider well all the conditions of the case, and will take care that the conclusions of their own designers are discussed and checked by outside authorities, that all their calculations are correct, and that at the last moment no flaw or slip be found, such as is usually accounted for by haste or oversight. There ought to be no chance of failure, and there need be none, if the competing firms, in their anxiety to obtain the order, keep continuously in mind that on no account must prices be cut so low as to render it doubtful if the best work and the best materials can be put in for the money. It is not a case of "Oh, that will do"; it is "the best, and none other."

It may be purely a question of coincidence that just about the time when the City authorities have decided to issue tenders for electric lighting, the gas companies and the advocates of oil are showing all they can do in lighting. Special improved gas-lamps, and special oil lamps are to be placed, or are placed, in certain streets to show that lighting by these means can be made quite satisfactory, and, of course, more cheaply than by the newer illuminant. It is positively amusing how quickly jeopardised interests find how much they can improve their wares when the market they long held as a monopoly is threatened. We trust, therefore, that the electrical industry will follow the example of the gas industry, and instead of each member trying his best to show his trade competitors in the wrong, there will be more pulling together for a common object than of bitter rivalry to frustrate business. All firms cannot get these contracts, and the motto rigidly adhered to should be "Fight fair!"

THE EFFICIENCY OF METHODS OF ARTIFICIAL ILLUMINATION.*

BY EDWARD L. NICHOLS, PROF. OF PHYSICS IN CORNELL UNIVERSITY.

Of human industries of the present day none, perhaps, save those which have to do with providing the race with food, clothing, shelter, and fuel, is more important to the cause of material welfare than that which deals with the production of artificial light, and he who seeks a means of measuring the material civilisation reached by a nation might find an excellent criterion in the progress which it exhibits in the art of illumination.

The problem of comparing the various methods of artificial lighting which are in vogue at the present day is one of great interest, whether we view it from the commercial standpoint, taking the cost of production as our controlling factor, or from the broader basis of relative usefulness, cost being relegated to a secondary position, or, finally, from the purely scientific point of view. From whichever side we approach this question, we are led inevitably to the consideration of certain elements which are alike of scientific, utilitarian, and commercial importance.

At first sight the attempt to determine the relative value of two sources of light would seem to be a simple matter. The number of factors, however, which enter into such a determination is surprisingly large, and many of them are of a character which makes it difficult to give them definite and complete expression. Of these the greater part are indeed commonly left out of account altogether, for the sake of simplicity, and we content ourselves with an antiquated and totally insufficient measure of our sources of illumination, which we call candle-power. It is to these other elements which enter into the question of the character of artificial light—such, for instance, as have to do with its quality—but which are, as a rule, quite lost sight of, to which I would ask your attention this evening, together with a discussion of those which are commonly made use of in photometry. If, in doing so, I am led to speak of methods which belong to the realm of pure science, I trust that you will agree with me in thinking that the results are not unimportant even to those whose interest in the problem of the production of artificial light is purely utilitarian.

In the important question of the efficiency of a light-producing machine or process, the practice of to-day is very far from having reached that degree of exactness of expression which we demand in other cases of the transformation of energy. In electric lighting the energy expended is readily determined in absolute measure, or in that excellent practical unit, the watt. In lieu of any attempt to express the useful energy obtained, however, we still content ourselves in practice with that most unscientific unit, the candle-power, based upon a source of illumination which is particularly subject to fluctuations of intensity and colour. Even as used in the Bunsen photometer the shortcomings of the standard candle are sufficiently apparent, but no one who has not attempted to study it by methods which make it possible to detect changes of colour as well as of brightness, can fully appreciate its fickleness.

* A paper read before the American Institute of Electrical Engineers, March 12, 1889.

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Such as it is, we do not, moreover, make the best of the standard candle as a basis of comparison of artificial lights. We speak of a 16-candle incandescent lamp, for instance, meaning oftentimes "mean spherical candle-power," and then we compare it with a petroleum or gas flame, measured in the horizontal plane only, much to the disadvantage of the electric lamp. The study of the distribution of intensities in accordance with the very complete system devised for that purpose by the Franklin Institute Committee in 1884, affords an invaluable means of comparing the performance of various types of incandescent lamps; but the adoption of "mean spherical candle-power" as obtained by that method is, to say the least, misleading when it comes to the comparison of electric lamps with candles, oil, or gas. It is to be hoped that when the present confusion of methods of measuring candle-power now existing in the electric lighting establishments in this country is supplanted by a recognised system, the fairer standard already established by law in England—viz., mean horizontal candle-power—may be adopted. It is, however, in the comparison of arc and glow lamps that the latter are put at the greatest disadvantage. Here we pit the incandescent lamp, using mean spherical candle-power as our basis, against candle-power measured at the angle at which the arc light sends out the greater part of its rays. Indeed, in too many cases it is not with the actual intensity, even in this most favourable position, with which we have to do, but with an estimated or "nominal" candle-power which the arc, in matter of fact, never approaches.

The electric arc stands quite alone for the purposes to which it is adapted, and need fear no rivals. It does not need to be estimated upon any fictitious basis, and the continuance of the pernicious practice of ascribing to it powers of illumination which it does not possess must, in a great measure, be charged to the account of the standard candle; for, with the best intentions in the world, the comparison of sources of light differing so widely in colour as the candle and the electric arc is nothing more than a rude approximation, leading by its very inaccuracy to the temptation of the grossest exaggeration.

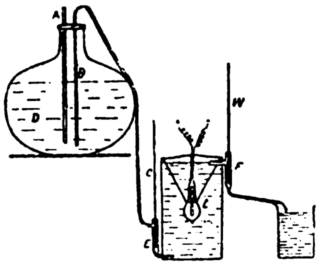

FIG. 1.

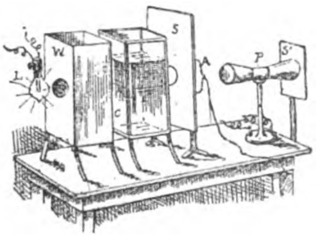

FIG. 2.

There are, fortunately, better methods of estimating the efficiency of a lamp than that which is based upon candle-power.

We may, for instance, determine the ratio of the energy of the light-giving radiation to that of the total radiation of the source of illumination. The efficiency of the incandescent lamp, according to this definition, has been recently determined by Mr. Ernest Merritt,* of the Physical Laboratory of Cornell University. Mr. Merritt followed two independent methods of investigation. In his first experiments the lamp was placed in a calorimeter constructed entirely of glass, Fig. 1, through which a constant flow of water was maintained. The temperature of the water upon entering and upon leaving the calorimeter was measured by means of the thermometers E and F. From this difference of temperature and the amount of water discharged in a given time, the heat absorbed by the calorimeter was calculated, proper corrections for loss of heat by radiations, etc., being applied. Now the water with which the calorimeter was filled is nearly transparent to the light-giving radiations from the lamp, and almost entirely opaque to the longer wave-lengths which constitute the so-called heat spectrum. To have assumed it to be entirely so, would, however, have involved very considerable errors, and the diathermancy of the calorimeter on the one hand, and its power of absorbing the luminous wave-lengths on the other, were accordingly carefully determined by methods long since elaborated and made use of by Melloni and by his distinguished English follower, Prof. Tyndall. By applying these and other necessary corrections, we are able to calculate very accurately in watts the non-luminous radiation from the lamp. The ratio of the total radiation, obtained either by submerging the lamp in a metallic calorimeter or by direct computation from the current and E.M.F. gives the actual efficiency of the lamp considered as a light-making machine. The result is not a gratifying one, when we compare this process with most others in which energy is transformed.

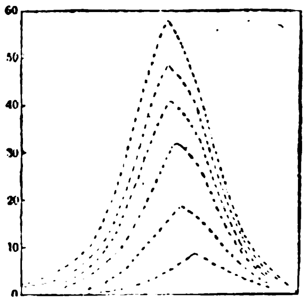

FIG. 3.

The efficiency of the best types of incandescent lamps, previous to the introduction of the recent three watts per candle lamps now in successful operation, which would doubtless make a somewhat better showing, was found to be rather under than over 5 per cent. at normal candle-power; the values ranging from 5 per cent. to 6·5 per cent. The last-named value for the efficiency was attained only at a temperature incompatible with any considerable length of life. The results obtained in this investigation are shown in Table I.,* and in the accompanying diagram, Fig. 3.

TABLE I.†

Lamp A.—Edison.

E.M.F.	W.	C.P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
74·2	34·6	0·9	0·18	0·005	0·59
91·6	56·2	4·8	0·68	·012	0·14
97·3	64·6	7·3	1·13	·017	0 15
100·3	69·3	8·9	1 62	·023	0·18
107 6	81·6	14·6	2·97	·036	0·20
109·3	84·4	16·3	4·57	·054	0·28
124·1	115·4	38·2	7·46	·065	0·19

In this table W is the total energy in watts; L the energy of the light, also measured in watts; and C.P. the candle-power.

(To be continued.)

SPECIFICATION.

SPECIFICATION OF CONDITIONS FOR SUPPLYING THE CITY OF LONDON WITH ELECTRICITY.

1. The main thoroughfares and public streets, etc., of the entire area of the City are to be lighted by electricity, and are divided into three districts. The contractors are at liberty to tender either for one or two of the districts or for the entire City. The Commission reserve to themselves the right of not accepting the lowest or any tender, or not accepting the whole or any part of any tender.

2. The area of the City which is to be lighted is divided into three districts as follows, and these districts are shown upon the plan accompanying this specification.

No. 1, West District, as marked on plan, comprising the area bounded on the north by the City boundary, on the east by Aldersgate-street, St. Martin's-le-Grand, St. Paul's-churchyard (north side), Creed-lane, and St. Andrew's-hill, and thence along Queen Victoria-street to Blackfriars Bridge; on the south by the Victoria-embankment; and on the west by the City boundary.

* Ernest Merritt, *American Journal of Science*, vol. 37, p. 167.

* Dr. Blattner, in an Inaugural Dissertation, published at the University of Zurich, gives similar values for the efficiency of the incandescent lamp. He finds, as the result of extended measurements with the glass calorimeter, that . . . "at the normal temperature of incandescence, where the intensity lies in the neighbourhood of 16 candles, the efficiency does not rise above 5 per cent. to 6 per cent." Emil Blattner: *Der Optische Nutzeffect der Glühlampen*, Frauenfeld, 1886.

† Tables I. and II., and Figs. 1 and 2, are taken from Mr. Merritt's paper, already referred to.

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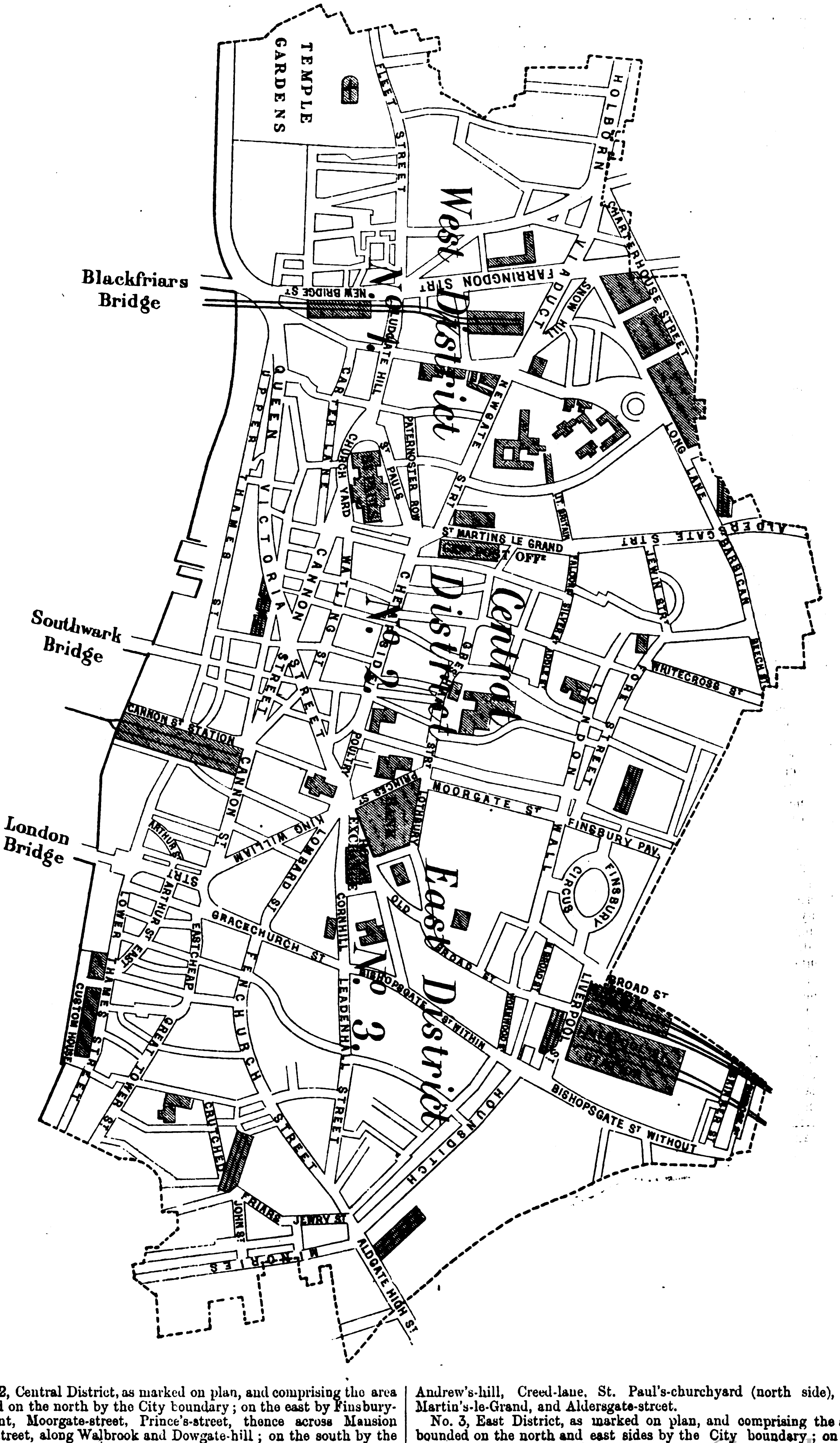
CITY OF LONDON ELECTRIC LIGHTING, 1889.



Plan Showing Proposed Districts.—Scale, 6 inches to a mile.

No. 2, Central District, as marked on plan, and comprising the area bounded on the north by the City boundary; on the east by Finsbury-pavement, Moorgate-street, Prince's-street, thence across Mansion House-street, along Walbrook and Dowgate-hill; on the south by the River Thames; and on the west by part of Upper Thames-street, St. Andrew's-hill, Creed-lane, St. Paul's-churchyard (north side), St. Martin's-le-Grand, and Aldersgate-street.

No. 3, East District, as marked on plan, and comprising the area bounded on the north and east sides by the City boundary; on the south side by the River Thames; and on the west side by Dowgate-

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hill, Walbrook, Prince's-street, Moorgate-street, and Finsbury-pavement.

The whole of the main thoroughfares in each district are to be lighted, and the following is a list of those thoroughfares:

District No. 1 (west): Holborn, Holborn-viaduct, Newgate-street, Charterhouse-street, King-street, Long-lane, Snow-hill, Chancery-lane, Fetter-lane, St. Andrew-street, Shoe-lane, St. Bride-street, Farringdon-street, New Bridge-street, Old Bailey, Fleet-street, Ludgate hill, St. Paul's-churchyard (north side).

District No. 2 (central): Barbican, Beech-street, Fore-street, London-wall, part of (west of Moorgate-street), Gresham-street, Cheapside, Poultry, Watling-street, Cannon-street, part of (west of Dowgate-hill), Queen Victoria-street, Upper Thames-street (west of Dowgate-hill), Aldersgate-street, St. Martin's-le-Grand, St. Paul's-churchyard (south and east sides), Wood-street, King-street, Queen-street, Cripplegate-buildings, Milk-street, Aldermanbury and Aldermanbury-postern, Coleman-street, Basinghall-street.

District No. 3 (east): Liverpool-street, Houndsditch, London-wall (east of Moorgate-street), Old and New Broad streets, Bishopsgate-street-Within and Without, Lothbury, Threadneedle-street, Cornhill, Leadenhall-street, Lombard-street, Fenchurch-street, Aldgate, Aldgate High-street, Gracechurch-street, Mansion House-street, King William-street, Cannon-street, part of (east of Dowgate-hill), Eastcheap, Great Tower-street, Upper Thames-street (east of Dowgate-hill), Lower Thames-street, Arthur-street East, Minories, Prince's-street, Moorgate-street, Finsbury-pavement, Arthur-street West, St. Mary-axe.

3. An ordnance sheet (88ft. scale) is to be sent in by those tendering with each tender, upon which sheet must be marked every one of the existing gas lamps, distinguishing those which are upon brackets from those which are upon columns. It must also show clearly the positions of the arc lamps and the glow lamps which are intended to be substituted for gas lamps, and indicate clearly the gas lamps which will not be required whilst the electric lighting is in operation. A specimen plan is attached to this specification, showing how the various lamps are to be indicated upon the plans to be sent in by the contractor.

4. The contractor must give a complete description of the lamps proposed to be used, of the power in watts they consume, and of the light in candles they emit, both of the arc and the glow lamps. The lamps must be so placed that the light distributed over the public ways shall be as uniform as possible, and those tendering will have to demonstrate upon a plan and section, which is to be sent in with the tender, the relative intensity of this distribution of the electric and gas light. The standard of reference will be the illumination of a square foot of surface by a standard candle at 12·7in. distance.

5. The situations of the stations for the generation of electricity, if within the City, are also to be shown, and if not within the City, the points at which the main conductors are to enter the City.

6. The proposed positions of the mains and service pipes or leads, both for public and private lighting in every thoroughfare, must also be shown upon the ordnance sheet.

7. The system by which it is proposed to supply electricity must be fully described.

8. So soon as the main thoroughfares in the district have been lighted by electricity, the contractor must proceed to light the remainder of the public ways when called upon so to do by the Commission.

9. If the contractor should desire to light, in the first case, any portion only of the entire City, or, as the case may be, any portion only of any one of the districts, and to light the remaining portion of the City, or of such district or districts, at a subsequent date, the area which it is proposed to light first must be indicated clearly upon an ordnance sheet. The tender must also specify the dates and conditions under which the lighting is proposed to be extended by the contractor to the other parts of the City or district, it being, however, understood in all cases that the main thoroughfares, a list of which is hereinbefore given, are to be lighted by electricity in the first instance.

10. The contractor must specify the price per annum at which he will light and maintain each of the lamps, both arc and glow, according to the conditions of this specification.

11. The whole of the lamps are to be lighted nightly, including Sundays, from sunset to sunrise, and at such other times as the Commission or their engineer may consider necessary, on account of fogs or other emergencies. Payment will be made in respect of such extra lighting on the certificate of the engineer.

12. The existing system of gas lighting must not be interfered with, but the contractor may, in certain cases, be permitted, by the consent of the engineer to use any of the existing gas-columns or brackets. The existing gas-fittings are not to be disturbed, but must be maintained perfectly intact, in such condition that the gas lamps can be used at any time they may be required, and the full unobstructed light from the burners obtained.

13. If, during the carrying out of the works, the gas lighting shall be accidentally disturbed, temporary means of lighting shall be provided by and at the cost of the contractor.

14. Where existing gas standards are not used, as provided for by clause 12, then the contractor must provide and fix special columns or supports for the electric lamps. A design and description of them must be submitted to, and be approved by, the Commission before any are erected.

15. The electric lamps must be fixed on such standards as the Commission may approve. Should any variation of the positions of the electric lamps be deemed desirable, the contractor must fix them in such positions as the engineer may determine. The contractor must also maintain, paint, and keep in thoroughly good order all standards, columns, brackets, and lamps, at all times, to the satisfaction of the engineer.

16. If in the opinion of the Commission, any public way or portion of a district can be better lighted by glow lamps, or by arc lamps as the case may be, of a less intensity than that stipulated in the contract, the contractor is to change and maintain such altered lamps without further charge to the Commission, provided the total consumption does not exceed that stipulated by the contractor in the tender for lamps throughout the district or the City. But if a less light should be required by the Commission, then a reasonable deduction in the price to be charged annually for such lamps shall be made, as shall be determined by the engineer.

17. If the Commission shall at any time require any alteration in, or addition to, the mode of public lighting, after the lamps have been once fixed, either by placing the lamps in a different position, or by substituting a smaller number of larger lamps, or a larger number of smaller lamps, or by replacing existing lamps, columns, or brackets by others of a different nature, or otherwise, such alterations shall be carried out by the contractor, subject to the supervision of the engineer.

18. The cost of making the alteration referred to in clause 17, both as regards removing old lamps and fixing new ones, shall be borne by the Commission, and should any question arise as to the amount of such cost, it shall be referred to arbitration, the question being referred to two arbitrators, or their umpire, and subject to the provisions of the Common Law Procedure Act, 1854, or any other subsisting statutory modification thereof.

19. All mains, conductors, and service wires, both for public lighting and private supply, shall be laid beneath the public ways, in such places and in such positions as shall be prescribed by the engineer, should any deviation from the plans sent in by the contractor be deemed by the engineer desirable, and all such mains, conductors, and service wires shall be maintained by and at the cost of the contractor in good order and condition.

20. The contractor shall in no case break up or interfere in any way with the streets, pavements, or road ways until 48 hours' notice of the intention to do so has been given in writing. Exemption may be claimed from this rule on the score of emergency only, and the contractor shall abide by such conditions as the Commission may impose from time to time for the breaking up and reinstatement of the pavements so disturbed.

21. The contractor must take proper and efficient precautions for protecting from disturbance or damage all telegraph and telephone wires, and shall abide by all statutes, regulations, and enactments, and shall hold the Commission harmless from any damage that may arise. The contractor will also be responsible for complying with all the requirements of the Postmaster-General.

22. Should it be necessary for the contractor to run mains through districts which are not included in his contract, the contractor must do nothing that will interfere with the supply of electricity by other contractors in the other districts.

23. The contractor must, in all cases where practicable and permission can be obtained, make use of the subways for laying the mains, conductors, and wires; but where no subways exist they shall be laid, where practicable, beneath the footways.

24. All works, whether upon, above, or below the public ways, are to be done at such times and in such manner as may be necessary for the public convenience, and subject in every respect to the control and direction of the engineer, whose directions on all points shall be strictly complied with, and whose decision on all points shall be conclusive, final, and binding on all parties.

25. Before the expiration of —— months from the signing of the contract, the contractor shall commence the work necessary for installing and providing the system of public lighting in each district, and will from the time of such commencement diligently and without interruption proceed with such work, and will complete the system of public lighting in all the main thoroughfares, on or before —— months from the date of such commencement. [The time to be stated by the contractor.]

26. To secure the due fulfilment in all respects of clause 25, the contractor upon signing the contract shall deposit the sum of £1,000 in respect of each district with the principal clerk to the Commission, this sum to be placed on deposit at the risk of the contractor in one of the London joint-stock banks, and with the interest accrued thereon shall, in the event of the engineer certifying that default has been made by the contractor in commencing or completing the works, be retained by the Commission as liquidated damages, and the Commission may at their option terminate the contract by giving notice in writing to the contractor. In case the engineer shall not make any such certificate of default the deposit, together with the accrued interest, shall be repaid to the contractor.

27. When pavements are disturbed, the paving contractors to the Commission must be in all cases employed to reinstate them, and they will do so at the contract prices which the Commission pay to the respective paviors and paving companies for such work, whether it be granite, stone, asphalte, wood, or other material, and any work which may be rendered necessary to the sewers, or their appliances, must also be made good by the sewer contractors to the Commission, at the cost of the contractor for electric lighting.

28. The contractor is to supply the electricity, conductors, carbons, glasses, lamps, attendance, and everything necessary for the effectual maintenance of the installation, and the lighting of the district, during the contract period. The whole of the plant and installation is to be the property of the contractor, and at the expiration or determination of the contract with the Commission for public lighting by electricity, all connections and fittings supplied or used exclusively by him for public lighting shall be removed by the contractor, and all paving, and everything else disturbed, shall be reinstated by, and at the cost of, the contractor. In the event of the contractor failing to remove the connections and fittings, and restore the paving, the same may be removed and restored by the Commission, at the cost of the contractor,

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29. So far as the Commission are able to do so, they will grant to the contractor the exclusive right of supplying electricity for private purposes within the district during the term of the contract. The contractor will be required to supply electricity to any owner or occupier of any premises within a distance of 25 yards of the mains, provided the owner or occupier enters into a fair agreement to defray, or divide, the cost of the service main, and to pay for the supply of the electricity. The contractor can charge the consumer for the amount of electricity supplied either (1) by meter, or (2) by agreement. (1) If by meter, the charge will be either by the actual quantity of energy supplied as measured in "units"—each unit being equivalent to 1,000 watts per hour; or by the mean average current expressed in amperes per hour, multiplied by the number of hours of supply. (2) If by agreement, the charge will be at the rate of so much per annum per standard lamp of 50 watts. The contractor will be required to specify in the tender the mode of charging selected, and the rate of charge.

30. At the expiration of determination of the contract for public lighting, the contractor is to have the right to continue to supply electricity for private purposes within the district, and to enjoy free way-leave, so far as the Commission are able to grant it, for all mains and service leads, concurrently with other parties, subject to the conditions for regulating the laying of mains and other works, and provided the contract has not been determined by the Commission for the following reasons: (1) under the 26th or 39th clauses, (2) in consequence of the contractor ceasing to supply electricity for private purposes for a continuous period of one month.

31. The Commission may at all times whilst the contract is in force test the condition and efficiency of the mains and conductors for insulation and conductivity in such manner as they deem desirable, and the contractor shall afford every facility for this purpose, and shall provide proper testing places and testing conveniences, and shall repair any defect that may be detected within a certain specified period, in default of which a penalty of £20 per day will be exacted so long as the defect continues.

32. The Commission may forbid the use of any main or conductor which they may consider dangerous to public safety, and may order its removal.

33. In the event of temporary failure in the electric lighting, the Commission are to be at liberty to light the streets by gas, or any other method, and all expenses consequent upon their so doing shall be paid by the contractor on demand, or the same may be retained out of any moneys due or that may become due to the contractor. The contractor will be liable to a penalty of 40s. per lamp for any and every instance of failure, or default in supplying light in any public lamp for any period exceeding five minutes, without prejudice to the rights of the Commission under clauses 37 and 39.

34. The contractor will be held responsible for any accidents or damage that may arise from imperfect lighting, or from laying or fixing conductors, lampposts, brackets, or from any cause whatever which may arise from carrying out this contract, and shall hold the Commission harmless for all consequences that may ensue.

35. Payment will be made at the end of every six months, upon the certificate of the engineer that the contract has been duly fulfilled, and the first half-yearly payment shall be made at the expiration of six months from the commencement of the public lighting, unless such period occurs during any vacation of the Commission, in which case the money shall not be paid until three weeks after the meeting of the Commission held next after such vacation.

36. If the profits arising from this contract exceed a cumulative dividend of 10 per cent. per annum upon the capital invested, the excess is to be divided equally between the contractor and the consumer. In other words, the contractor will not be entitled to pay a dividend of over 10 per cent. per annum, calculated from the commencement of the contract, unless at the same time the cost of the supply of the electricity to the consumer is reduced at the rate of ½d. per unit, as per schedule, for each 1 per cent. added to the dividend.

37. The duration of the contract for public lighting is for a period of 21 years from the completion of the lighting in all the streets, and shall be subject to determination by the Commission if the lighting, upon the certificate of the engineer, is inadequate or inefficient, or if the plant and system have not been maintained in thorough efficiency, any dispute as to the inadequacy or insufficiency of the lighting, and of the maintenance of the system, to be referred to arbitration, without prejudice to the rights of the Commission under clauses 26, 33, and 39.

38. The Commission shall have the option, by giving three months' notice in writing, prior to the expiration of the term of 21 years, to renew the contract for public lighting for a further period of seven years, and so on from seven years to seven years by giving a similar notice. Each renewal is to be subject to any revision of terms which the success of the contractor or the improvements introduced in supply or lighting may suggest.

39. In the event of the contractor failing, after receipt of due and formal notice at three separate times, with proper intervals, to comply with the conditions of the contract, to maintain the plant, mains, and conductors in proper order, and to provide sufficient electricity, the Commission shall have an immediate power to determine the contract as to public lighting, and to order the removal of the mains and conductors, whether used for private or public lighting. Any dispute as to the inefficiency of the lighting, or as to the failure of the supply, is to be referred to arbitration, without prejudice to the rights of the Commission under clauses 33 and 37.

40. Power is to be reserved to the Commission to acquire the undertaking and works, by purchase at the end of 21 years, or each succeeding seven years, on giving six months' notice, in accordance with section 2 of the Electric Lighting Act, 1888.

41. A contract embodying this specification, and such other provisions as may be deemed necessary by the Commission, is to be entered into by the contractor.

42. The contractor is to fill in his tender upon the following form. He may, at the end of such tender, give any descriptions or make any remarks he thinks proper, or anything that he may consider illustrative of his tender.

FORM OF TENDER.

To the Honourable the Commissioners of Sewers
of the City of London, 1889.

Gentlemen,

hereby undertake to light the district No. , coloured on the accompanying plan, in accordance with the accompanying printed and signed specification, on the following terms—viz.:

(1) Description of the lamps and their power; (2) the system on which it is proposed to supply electricity; (3) date of commencement of work and of completion of public lighting; (4) date within which the remaining portion of district or City shall be lighted completely under clause 9; (5) price per annum, under clause 10, of (*a*) arc lamps, (*b*) glow lamps; (6) mode and rate of charge for a supply of electricity for private purposes.

UNDERGROUND CONDUITS AND ELECTRICAL CONDUCTORS.*

BY JOHN B. VERITY (MEMBER).

My object in bringing this subject before you this evening is to promote an interchange of opinion and experience concerning one of the few remaining problems connected with the general distribution of electricity in our cities. Since I began to write this paper on my return from America, much information has appeared in the electrical press, and the close attention now being paid to the matter in America is equalled by a like spirit of enquiry here. The outcry against overhead wires has been gaining in force, and although the numerous objections urged are devoid of solid grounds, there is a general feeling that any considerable extension of overhead cables for electric lighting is impossible, both on account of the difficulty, and no inconsiderable expense, in procuring wayleaves, and also the attitude taken up by the Board of Trade and others to put a stop to them. Overhead wires in this country may therefore be simply considered as a temporary measure to admit of the electric supply companies getting to work, and permitted only on the distinct pledge of the removal of such wires within a certain period.

The time allowed for the execution of underground works in provisional orders and licenses, although as long a period as could be obtained, is all too short, and a thorough discussion of the subject at the present time, in its numerous aspects, is highly advisable to enable it to be afterwards promptly and adequately dealt with.

In three months we may reasonably conceive that certain electric supply companies will be under legal obligations to at once face the problem of putting high-tension electric conductors underground. It will be no petty attempt narrowed down to a small area, but in two special instances the undertaking is proposed to be carried out on a large scale by companies of adequate financial resources, and with supply stations already erected or in process of erection.

"Is failure probable?" may seem a singular question to put here, but it is a necessary one, leading up to the various difficulties to be encountered, and in view of the alarmist statements at the recent Electrical Convention in Chicago, one that deserves prominence. Mr. Lynch's paper, giving the results of the working of underground cables, and which was practically the only part of the meeting reported in the English papers, showed but one side of the case, and from the discussion following it (and which appeared in the *Electrical World*, March 2) much was to be learned. Many of the companies operating underground cables had from some cause or other not given their opinions, and the failures alluded to were in several instances traced to defective conduits, insufficiency of insulation, poor insulation, imperfect jointing, and cheap work. Cheap work has damned electrical enterprise before now, and it behoves us all to guard against a recurrence of it. Anything also on the subject of conduits and underground electric conductors emanating from American electricians has to be carefully sifted, as not even are our Unionists and Home Rulers more defined than certain "overhead" and "underground" men in America. The overhead men accuse all the underground men of being interested in some of the dozen forms of conduits put forth, the underground men retaliate by saying, "You don't want to go underground," and "you boldly say we cannot go underground."

In England we stand on a different footing altogether; if much more electric lighting work is to be done, we must go underground, and having recognised that, how can it best be done? The necessity and best form of conduits are the first points for discussion.

The successful working of a system of underground electrical cables in a city must be linked to an arrangement of ducts, as the impossibility without such of getting at the cables for repairs, inspection, tapping, and alterations is evident. Even if the local authorities remained quiescent during any continual disturbance of our streets on account of electrical conductors, commercial interest must prevent such occurring. The expense of opening up a crowded thoroughfare to lay underground cables is in many cases as great as the cost of whatever is being laid, while by using a duct this expense, once incurred, should not be again necessary. Again, if the cable be laid in the ground without a duct, it is necessary to armour it, and lay it down at first equal to all possible requirements, otherwise any extension of the lighting beyond

* Paper read before the Institution of Electrical Engineers.

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the capacity of the cable would necessitate a repetition of the whole original work. In this case, the first cost of such a large cable would be nearly as great as the smaller cable and duct together. Finally, the life of the best cable for high-tension currents cannot at the present be predicted, and this, together with the other reasons, undoubtedly prove that a conduit with a drawing in and out system is eminently desirable.

An ideal system for underground work is a brick subway, well drained and ventilated, and of sufficient size to permit of a man working in it; failing this Utopian arrangement, what comes next best? In New York, where the matter has been placed in the hands of a Board of Electrical Control, they start out by saying that a conduit or subway for electrical conductors is nothing more than a mechanical protection for the wires within it, and a convenience for placing or putting them underground. In their experience of three years the Board of Electrical Control have naturally tried and abandoned many conduits. In a room of the Telephone Building, New York, occupied by the Subway Construction Corporation, there is a heap of experience—experience gained at no little cost—that it would be of advantage for engineers who lightly propose undertaking such work to see and meditate on. Wooden conduits, bitumen conduits, asphalte conduits, earthenware conduits, samples of underground conductors, all are here in what is termed the museum, and afford a collection of failures most instructive as to what not to do.

In many instances, however, the conditions there would not apply to England. At present we have no system of steam-heating with leaky pipes, causing trouble wherever they go. Again, here we have not those great extremes of heat and cold, the frost compelling conduits to be laid at an average depth of 4ft., and the heat causing various troubles with asphalte and bitumen conduits. At the same time from the numbers of miles of conduits laid down there should be something to learn, and I therefore propose instancing some of the more important conduits known in America and elsewhere.

Conduits are divided into two classes: the so-called solid conduit, and the hollow conduit. Solid conduits are useless considering here, as they practically consist of cables bedded in asphalte or bitumen, which means ripping up the ground, and breaking the enclosing mass if alterations are required. With hollow conduits, the difficulties to be encountered seem to be to provide a smooth channel with convenience for drawing in and out to prevent explosions through accumulation of gas, and to keep them reasonably dry and water-tight.

In the discussion at Chicago it was stated that in one instance it was necessary to keep a blower going to ventilate an iron conduit, while several authorities appear to consider it advisable on dry days to take off the manhole covers. Accidents have, of course, occurred from conduit explosions, and the engineer of the United States Electric Lighting Company instances one where the manhole covers of the conduit were blown over the roof of a four-storeyed building. But in England, again, the work done by the gas companies is far better, and the leakage in our streets is not in any way to be compared with the quantity of illuminating gas which wanders fancy free through the soil of many cities in the United States.

It appears desirable that conduits should be ventilated; and the form adopted, where possible, is to ventilate them by means of a pipe running into the base or up the interior of the street lamp-posts. With regard to keeping them water-tight, this is another constructional question, surely capable of being properly dealt with.

Many of the complaints of leaky conduits and ultimate failure of cables I trace back to the Dorsott conduit.

This, one of the earliest forms of conduits, is built of blocks formed of a combination of cold tar pitch and fine gravel, cast with tubular openings 2½in. in diameter running through them from end to end. They are jointed by pouring soft mastic into the cracks between them, and the blocks made to adhere to this by warming their ends with hot irons and allowing them to cool, after being well set. To prevent the melted mastic from closing the ends of the passages, tubular pieces of paper are inserted, making a sort of internal sleeve coupling. The conduit so formed terminates in brick manholes at the street crossings. The objections to this conduit are that it is brittle, porous, inelastic, and cracks with changes of temperature, so that it is not likely to be made water-tight with average workmanship.

Creosoted wood conduits have been extensively used in the States, and have been a leading cause of trouble and failure with lead-covered cables. A chemical action takes place between the crude creosote and the wood, setting free acetic acid and carbonic acid gas, which, reacting on the lead pipe, converts its surface into a film of acetate of lead; the action continuing until the entire sheathing is converted into carbonate of lead or white lead. Creosote is also said to rot rubber. There are, of course, ways of overcoming such troubles, but as I do not think we shall be disposed to use creosoted wood conduits in this country the matter need not be given much prominence here.

The difficulty of obtaining a conduit that shall be anything more than a mechanical protection for the cables is certain to be great, as however good the insulating material forming the conduit may be, and however water-tight the joints, there is a difficulty in excluding dampness unless it is practically airtight, as damp air enters the conduit and condenses on it.

Several conduits have been made, however, with a view to afford electrical as well as mechanical protection to the cables. The Callender bitumen conduit, for instance, is well known here. It is being extensively laid down by the Chelsea Electric Lighting Company, and 500 yards of it is being tried by the Metropolitan Electric Supply Company. For high-tension currents its use is doubtful, but, perhaps, in the discussion something may be said on this point.

Vitrified 3in. sewer pipes laid in concrete with cement joints have been used in some instances for underground work.

(To be continued).

BOARD OF TRADE ENQUIRY.

Major Marindin, C.M.G., R.E., on behalf of the Board of Trade, resumed the enquiry at the Westminster Town Hall, on Wednesday, April 10th, for the purpose of hearing, on the part of a number of electric lighting corporations, their provisional orders to erect and maintain electric lines and works, and to supply electricity within certain areas in the metropolis and elsewhere, and the objections raised thereto by other companies and corporate bodies.

The case of the Metropolitan Electric Supply Company came on for hearing.

Mr. C. A. Cripps, who represented the Company, said he hoped to put shortly before the inspector on the part of the Metropolitan Electric Supply Company, Limited, their views with regard to the provisional orders which they were now asking from the Board of Trade. He would like to state at the outset, in order to make his address as short as possible, that there seemed to be two main points that could be very easily established to the satisfaction of the Board of Trade. The first was that the company he represented were in a thoroughly sound financial position, that they were supported by men in financial circles, that they had ample capital for all that they proposed to undertake, and that if additional capital were necessary they would have no difficulty in finding it. The other point he hoped to make equally clear was that the system proposed to be adopted by that company was the best and safest, that from an economical point of view it would stand comparison with any other system, and that as regarded safety and convenience to consumers, it stood in the best position of all. It had not been necessary for him to cross-examine on those points, or criticise at any length the views put forward on behalf of the London Electric Supply Corporation, and they were not desirous of doing so for the reason that they were so assured that when the inspector had heard their full evidence, they need not fear any competitive system put before him on behalf of any other company. They were not, in fact, concerned unduly to criticise any other system brought before him. The capital of the company was £500,000, in £10 shares. He believed that when the capital was issued, the amount subscribed was double what they wanted. Of the amount subscribed, £3 per share had been paid up, and the number of shareholders was no less than 700. They had expended a sum of £380,000. As he had already suggested—and he thought that Major Marindin would be satisfied with it when he had heard the evidence—whenever any further expenditure was necessary in order to carry out the obligations which the Metropolitan Company were desirous of incurring, there would be no difficulty whatever in finding sufficient financial support. The districts which they proposed to include for the purposes of electrical supply were comprised, in the first instance, under four provisional orders. As regards one of those orders, the North London order, he might state that after careful consideration, the directors of the Metropolitan Electric Supply Company did not propose in that enquiry to ask for any compulsory powers at all. In fact, in so far as that order was concerned, they withdrew that application, and nothing more would be heard about it. He mentioned that in anticipation of any of the views put forward by the local authorities, because that determination had been come to at a late moment. The first order upon which they would ask his (Major Marindin's) decision was the mid-London order. Now the mid-London order was shown by the map handed in, and his learned friend and the various local authorities had had full information as to what was comprised in the order. The area of supply constituted a number of parishes in the metropolis which he indicated on the map and over some of which the London Electric Supply Corporation also sought working powers. In order to supply electricity, he went on to say, to those various districts they proposed to have certain central or generating stations. It would be impossible to lay before the inspector any complete list of the generating stations until it was known for certain what districts they would be empowered to supply. They had made provisions as regarded a certain number of those generating stations, and he would give their names and situations as well as their capacity of lighting power. They had a station at Whitehall with a capacity of 12,000 lights. They had arranged for one in Sardinia-street with a capacity of 50,000, one at Rathbone-place with a capacity of 24,000, one at Manchester-square with a capacity of 50,000, one at Ecclestone-place with a capacity of 40,000, and one at Waterloo Bridge with a capacity of 20,000 lights. That was the present strength of the plant.

Major Marindin: Are these all arranged?

Mr. Cripps: Yes. The ultimate capacity of those stations if the lighting were required would be as follows: Ecclestone-place would be increased to 150,000, Waterloo-wharf to 75,000 lights. Whitehall station was running at that moment. Sardinia-street station would be ready in June, as well as that at Rathbone-place, while that at Manchester-square would be ready in July, Ecclestone-place in August, and Waterloo-wharf in September. In reference to the City, they had made satisfactory arrangements. In fact, they had practically purchased the wharf known as Greenmore-wharf. That would be a centre capable of supplying the City district. It was adjoining Southwark Bridge. They had up to the present time made no arrangements as to the plant there, but he believed that when they were carried out that wharf would be able to carry a plant capacity of 120,000 lights. He would now deal briefly with what their proposed system was, and say a few words as regarded its advantages and also certain suggested disadvantages. The Whitehall station supplied a very compact district, and was worked by means of the direct-current system and storage batteries. The electrical pressure over the district would be 100 volts, that in the engine-rooms being somewhat higher—between 100 and 110. There would be no transformers. As regarded the other generating centres, they would be all worked by what was known as the alternating-

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current transformer system—that was to say, there would be alternating currents of high pressure in the mains converted by means of an induction apparatus into currents of low pressure on the consumers' premises. The pressure in the mains would not exceed 100 volts, and in the house not more than 50 volts. He thought that, properly speaking, all their mains would be called distributing mains, because there were not distributing centres in addition to the generating centres. He was also sure that the inspector would be satisfied after hearing the evidence that the variation in constancy of pressure would not exceed ½ per cent., that slight variation being attained by limiting as they did the district supplied from the various generating stations. He thought that the proposal was that those stations should be from one to two miles apart, and of sufficient size to fully utilise the staff employed, so that any suggestion that was made as regarded economy of labour would be fully met by the size of those stations, and from an economical point of view it would be proved that they would be gainers by not having long-distance mains through which to send their electric current. Each centre would be completely fitted with the best-known machinery and of the most modern structure. That, of course, would be a matter of evidence so far as it was gone into. The mains would be copper wires insulated with vulcanised indiarubber, and covered with some other insulating compound. These would be drawn into cast-iron pipes, and there would be at convenient intervals testing-boxes, in order to minimise any breaking up of the streets, while as regarded the private supply there would be junction-boxes. Now, the reasons which dominated the company in adopting and bringing forward their system as the best were twofold. First of all, there was the advantage of actual experience. He would bring before them Mr. Siemens, of Berlin, and Mr. Spencer, of America, to show that the system had been tried and carried out to a large extent in both Berlin and the United States, and that practically it had been found to be most efficient. Not only from Berlin and America, but also from St. Petersburg would he bring evidence as to its effective working. In addition to that the company had been advised by the most eminent experts and scientific men on the subject, and a considerable number of them would be called to give evidence to show on what sound foundations the Metropolitan Company stood when they brought forward their recommendations. The advantages of generating centres might be very shortly stated, so far as his opening remarks were concerned. There was no necessity to have a high pressure, and therefore there was little difficulty in insulating the cables and the transformers. The cost of their mains would be much less than the system of the London Electric Supply Corporation, and in case of any accident to them—which, of course, they did not apprehend—the area affected would be very much smaller. In reference to that he might make this statement: that by means of the various generating stations the mains would be constructed so as to overlap one another, so that if at any time there was any special pressure of work to be done, one or more of those generating stations would come to their aid and give the requisite supply. Then he was instructed to the effect (and this was a matter of scientific detail which he need not now go into) that their sub-division of machinery tended towards an economical method of working. Before he dealt, however, with one or two suggested details as regarded the Metropolitan Company's system, he would like to make one or two remarks upon some of the general points raised by his learned friend, Mr. Pember. Mr. Pember said that the company he represented hoped to make of Deptford a sort of electrical Beckton. He (the speaker) ventured to suggest that whatever might be the scientific advantages of the London Electric Supply Corporation's system as against that of the Metropolitan Company, there was no analogy between it and a gas company undertaking as regarded their having their supply in or out of London. The objection to a gas company in populous places was the noxious vapours given off in the manufacture of gas, and more particularly in that of residual products. There was no difficulty to overcome in generating electricity as regarded noxious gases and other matters which made it expedient to remove the gas companies out of London.

The first suggestion made, as to the greater costliness of having various generating stations, had reference to the price of coal. It was sufficient for him at the present time to deny the suggestion of the greater cost of coal, for Lord Crawford, in reply to a question put to him on behalf of the Metropolitan Company, said that he was aware that what was called the cheaper coal could be used at small generating stations, although he was afraid that from his experience at the Grosvenor Gallery some nuisance might be caused. The next suggestion—a rather small matter to test such a matter by—was that there would be some saving in supervision. If all the operations were under one roof no doubt there would be some slight saving, but if all the labour was equally employed and as economically employed in various generating stations as in one, he ventured to say that that saving would be absolutely inappreciable. And, after all, it must be borne in mind that those generating centres were both generating and distributing stations, whereas the other system, having one large generating station at Deptford, must have various distributing centres within the district supplied. As regarded noise, vibration, and smoke, they were in a very sound position indeed, and he thought it could be shown, as the result of what the Metropolitan Company had actually done with the machinery that they had put up, that the suggestion put forward in connection with the Grosvenor Gallery station would have no weight as regarded their proposed generating station. There was a time when suggestions were made that a nuisance was caused by the generating station at Paddington. He would afford full evidence in regard to the matter, and it would be found that their engineer had been enabled to deal with the difficulties. No doubt there were difficulties at first, but they had been overcome, and no complaints were now made. As to the Whitehall station, no trouble had arisen in connection with it. He would now pass on to the form of the proposed order. In the main, he believed it was in the modern form.

Major Marindin: Do the three orders all agree?

Mr. Cripps: Yes. He would like to say before dealing with the various provisions in the order that he fully adopted what his learned friend, Mr. Pember, said as regarded a monopoly. They were not seeking a monopoly of supply. They relied on their system being the best and most efficient, and felt satisfied that they should get an adequate and good custom. They were aware that under the Act of 1888, in the first section, it was specifically provided that a provisional order was not to be regarded as a monopoly, and he adopted everything Mr. Pember said on that point. He would just deal with the opposition that they had to meet with regard to the various orders. He would begin with the mid London one. They found that the City and the Metropolitan Board of Works withheld their consent on the ground of protection as regarded the bridges. St. George's, Hanover-square, and St. Giles' District Board of Works withheld their consent, and St. Margaret's and St. John's Vestry, Westminster, had not given their consent, but they hoped with respect to the latter to overcome any objections. The next objection came from the owners of railways, tramways, and private property. As regarded private property, on the part of the Duke of Bedford and Smith's Trustees objections had been made under a misapprehension, because the company did not propose to take any compulsory powers whatever in respect of private property. As to the railway and other companies, the difficulty reduced itself to a question of the usual protective clause, and he was sure there would be nothing to prevent their framing one in accordance with ordinary precedent. Overlapping powers were asked for as regarded the various electric light companies opposing them, and with respect to the objections raised by the Thames Conservancy and the United Telephone Company, he thought there was a clause in the provisional order giving them what he considered to be ample protection. The company's desire was to give them that protection, and if in any particular they wished the order strengthened, so as to make that provision absolutely secure, the company were willing that it should be granted. As to the South London provisional order, he could only say that the company were anxious to do all they could to meet the wishes of the local authorities and any other bodies who might raise objections. The same might be said in respect of the West London order. The principles involved in the objections raised by the various local authorities and other bodies ought to be summarised under very few heads. First, there was the question of overhead wires. Well, first of all they were satisfied that under the public Act they would have no power to erect those overhead wires, and they did not seek for any powers in the provisional order. But they did not object to introduce the distribution of electricity under section 7 sub-section C of the Act, which provided "that nothing in this order shall authorise the undertakers to place any electric line above ground, along, above, or across the street without the express consent of the local authority." What he assumed on that point was that they could do nothing without the consent of the local authority, to which they had no objection. Another subject of disagreement was as to their capital not being sufficient, and a demand for security. There, again, to prevent repetition, he adopted the argument of his learned friend Mr. Pember, and considered that it was a condition precedent to their getting any powers at all that they should satisfy the Board of Trade as to their financial position. The company did not consider that it should be a question of giving security as one of absolutely satisfying the Board of Trade that they had ability to carry out the works they undertook. Then a question was raised as to the sale of the powers by the undertakers, which the company said they could not do, and which they did not ask for any power to do. But some of the objectors, not all of them, asked that the 42 years should be reduced to 21. There the company and they were absolutely at issue. They considered that the matter was settled by the Act of 1888, before the passing of which full evidence was taken on the subject. The company would make no concession, therefore, on that point. Then the question was raised as to the time within which the supply should be given, and the company proposed 18 months as a reasonable limit. As regarded the area over which they were asking for powers, their view was that they could work more economically and better having a large area, and by means of a company with a large capital, than they could on a smaller scale within more limited districts; and their point of view was that both the local consumers, as well as the company supplying them, would be benefited by the proposal the company now made as regarded area. It was also asked that if subways were made in the future the company should be compelled to place their mains at their own expense in those subways. He could only say that they would be glad to take advantage of subways wherever they existed, but he thought that no obligation should be placed upon them in regard to subways until the question actually arose. If subways were to be constructed, arrangements between the company and the local authority could be easily made, whereas as it was now a premature question. Questions were also raised as to the safety of supply which could hardly be raised with reference to the system which they proposed to adopt, but that was a matter which would be under the control of the Board of Trade. He concluded by referring to a few minor alterations in the orders which were proposed by the company in deference to the views of the local authorities.

Sir John Pender, chairman of the Metropolitan Company, was then called and examined by Mr. Lyttleton. He said that the authorised capital of the company was £500,000, divided into 50,000 shares of £10 each. He believed that 43,900 shares were applied for, and that there were 700 shareholders on the register, and that £3 a share had been called up. At the present time, therefore, £131,700 had been called up; £40,000 of that amount had been spent on the Whitehall station. The Whitehall Company was taken over when it was just starting. The company had since acquired the station at Rathbone-place, and were erecting stations in Sardinia-street, Manchester-square, Ecclestone-place, and at Waterloo Bridge. It had

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been his special business to deal with the financial side of the business. To establish those stations, the company had spent about £350,000 out of the £500,000, which in his opinion allowed for an ample margin for working capital and for extensions if they were required. If in the future extension became necessary or desirable, he had not the least doubt that they could raise further capital. In fact, he would not consider the company a success if they did not quadruple their present capital. They would have no difficulty in finding the money if the present installation gave the return anticipated. He did not at all object to wholesome competition.

Cross-examined by Mr. W. S. Wright, **Witness** thought that the object of all companies promoting electric lighting should be to make it satisfactory to the public as well as to the shareholders. If there could be any understanding which would facilitate the production of the light quickly and cheaply, the different companies should endeavour to do it. Their great object should be to obtain the cheapest light for the public that they could. The production of electricity was now in such a state that he would not be surprised if at any moment some wonderful discovery was made by which electric lighting would be greatly cheapened. His company were not bound by any system, but promoted that which they believed to be best suited to the locality in which they proposed to establish their business. Speaking as a consumer of electricity, he would prefer that there should be more than one system in a particular district—not, perhaps, if he were an interested shareholder in the company getting the provisional order. Those who did the work best were sure to get the most business. He did not think it likely that three or four companies would go into the same district for commercial reasons. It was his opinion that the Board of Trade should be the judges as to how many companies should be allowed to take possession of one district, so as to prevent the blackmailing of existing undertakings satisfactorily meeting the public demands. There was no limit to their capital powers, and if they found that in the districts they supplied the demand was in excess of what they were able to give in the way of electric light, they would issue debentures to an amount adequate to meet further extensions of their business.

Cross-examined by Mr. Russell Griffiths, he said that the company would ultimately turn their attention to giving motive-power over the area for which they sought their provisional order.

Mr. John Edward Henry Gordon (electrical engineer to the Metropolitan Electrical Supply Company) was next called and examined by Mr. Lyttleton: He deposed that at their Whitehall station they had experienced no difficulty as regarded noise, smoke, or vibration. It was quite possible, by using proper precautions, to get rid of all such difficulties. They intended to adopt the alternating-current transformer system in the scattered districts, and the pressure they would have in their mains would be 1,000 volts. They were making preparations for supplying 50,000 lights in Sardinia-street, and the work was being carried out by the Westinghouse Company. He found that that company had put up 120 or 130 central stations, and desiring to have the fullest benefit from it, they determined to put the lighting in its hands. At Rathbone place they were running 2,000 lights, but they had put in plant for 24,000 lights. They proposed to use the same engines and dynamos as those used at the Whitehall station. The station at Manchester-square would be capable of working 40,000; Willans engines and Elwell-Parker dynamos would be employed. At Eccleston-place, Victoria, they had premises capable of accommodating 150,000 lights, and they were putting in at once machinery sufficient for 40,000. Waterloo wharf would be one of their principal stations with accommodation for supplying a large number of lights. He thought there would be no difficulty there as to smoke or vibration. The Whitehall station was situated near more valuable property than any of the others. The amount that the company was spending on machinery was £195,000, on buildings £50,000, on mains from £80,000 to £100,000, he could not say exactly, to which had to be added the cost of sites, etc. The total amount was about £370,000. They intended to limit their pressure to 1,000 volts—the highest pressure which had been used in his experience was 2,500 volts. It was on the alternating-current system. There was no difficulty in insulation at that pressure. Their mains would be all underground. He proposed to place ordinary gaspipes from three to five inches diameter along the streets, and at every house a junction-box, so that in case it were required instead of having to open distributing-boxes they would simply have to take up one flagstone over the junction-box. At intervals of 200 yards he would place a testing-box, so that should anything have to be done to the mains the person doing the work could open the lid and pull the main through the pipes. At Paddington the chief nuisance arose from clouds of dirty smoke—one man going so far as to say that meat turned sour in his cellar. But the nuisance was absolutely stopped, and he had heard no further complaints.

Cross-examined by Mr. Pember, **Witness** said that the consumption of coal at Paddington never exceeded 100 tons a week. It was about 12 tons a day for 25,000 lights. All their coal would be taken through the streets from the wharves. He denied that there was any noise from the engine-room.

Cross-examined by Mr. Shiress Will, he said that they desired to adopt the experience of all countries.

By Mr. Wallace: They proposed to light only a small portion of St. Margaret's, Westminster. The mains could easily be drawn in and out of the street openings he referred to. It would not be necessary to draw out the whole length of a main in which some connection had gone wrong. Faults could be remedied by cutting the connection at a junction-box on each side, not at the test-boxes, pass a new length of main through, and connect it across before cutting the other, so that the only interruption would be between the two junction-boxes.

Cross-examined by Mr. Muirhead, he said that the alternating-current system could not be used with storage batteries.

By Mr. Russell Griffiths: The whole process of opening a testing-box would take about six hours, and could be done at night. He would place mains 12in. under the pavement, but in a road with heavier traffic it would be desirable to put them deeper. They would have no overhead wires at all. He preferred dynamos of about 200 h.p. each, from which they could get 4,000 lights.

Dr. John Hopkinson, examined by Mr. Lyttleton, observed that this system was adopted at many stations. With respect to uniformity of distributing electricity, it would be much more uniform unless they worked on an exceedingly high potential with few machines. Its great advantage was that as the consumption varied they could vary the number of machines employed during early morning and afternoon. With the Metropolitan Company's plan, it would, he thought, be impossible for the supply to fail in any district. They had carefully considered the question of adopting 10,000 volts or to go to 2,500, and came to the conclusion that, though there were some advantages in adopting the higher potential, they would be counterbalanced by the disadvantages of a possible breakdown in the mains or transformers. He believed that accumulators would run to £30 per horse-power in the maximum amount put in, and they lost 30 per cent. of power.

Cross-examined by Mr. Russell Griffiths, he said that the proper arrangement to prevent disturbance to telegraphic and telephonic wires would be that when there was a current going out there must be one coming back carrying the same current within six inches.

Dr. Fleming, recalled and cross-examined by Mr. Moulton, said that electricity furnished from storage batteries was favourable to the long life of a lamp, but he did not know that there was anything in an alternating current which would of itself shorten the life of a lamp. Assuming that they had constant voltage, the one would not give a longer life than the other.

Cross-examined by Mr. Pember, he added that he had had lamps to live 7,000 to 8,000 hours.

In further reply to Mr. Cripps, he said that the variations in pressure could be made lighter with the Metropolitan system than with batteries, because with the latter they must go by steps in one cell at a time.

Mr. Alfred Henry Walton, examined by Mr. Lyttleton, said he had been manager of the Paddington works since the Great Western took them over. There had been no complaints for two and a half years. There had been a slight alteration in the construction of the machines to get rid of nuisance. The field-magnets which revolve had pole-plates at the extremities, and the fixed coils on the machine were supposed to have one-eighth clearance all round. On one side of the machine they took out the coils, and shortened them on the top sides, so that they gave a quarter of an inch in front at the left-hand side, and a quarter of an inch on the back on the right-hand side. By this means the two sets of coils set up a different note, and so misconstrued one another, and the reduction of noise was found to be considerable. They ran 4,000 lamps of 25 c.p., and about 100 arc lamps from that station.

Mr. Thomas Spencer, examined by Mr. Cripps, said he was the engineer of the Westinghouse Company, and had considerable American experience, which company had adopted, by preference, the transformer system, which the Metropolitan Company were now proposing for London. One thousand volt pressure was adopted for the mains.

Prof. Forbes, examined by Mr. Cripps, said that in his opinion the system proposed by the Metropolitan Company was the best that at present could be adopted. It would preserve a high constancy. The loss in the distributing mains between the feeding points would not exceed ½ per cent. The constancy of pressure was better in high-tension than in a low-tension direct supply. The question of the transformers as to keeping the pressure constant was a point of the greatest importance. A fall could not be allowed of more than 3 to 4 per cent. between the hours of maximum and minimum supply. The wiring of the houses generally took 2 per cent. of this, the transformer itself would take 1½, bringing it to 3½ per cent., leaving usually 1½ to play with in the mains. The Metropolitan Company, however, having only one transformer, lost that 1½ per cent. only once. Their system was also highly economical. The E.P.S. was a very interesting but a very costly system, almost prohibitive from an economical point of view.

MONDAY, APRIL 8.

Prof. George Forbes (recalled) cross-examined by Mr. Moulton, said the Metropolitan Company intended to use the transformer system with 1,000 volts pressure, and his preference would be to have each distributing main connected while in action with only one generating source. He had been asked to examine the cost of batteries in many schemes, but had never had one in his own hands as engineer. He had gone into the question of batteries as a source of distribution very carefully quite lately in connection with the proposed lighting at Paddington by the Vestry, but it seemed prohibitive at present. Of course, there is a storage of energy in the accumulator system which there is not in the direct supply system. He had seen the transformer system in America, but had never seen it put to earth there. He thought to put the secondaries to earth a very good thing indeed, but he objected most positively to putting the primaries to earth. The system he had seen worked at Berlin was the most economical production of electricity for a central station in the world—that is to say, the combination of engines and dynamos with condensing arrangements, etc. There was less fuel used for the electrical unit given out in the central station than he had ever seen anywhere else. The greatest variation of pressure allowed in the mains at Berlin was 1½ per cent., which was, he thought, a proper regulation, but necessitated enormous expenses for mains.

Cross-examined by Mr. Russell Griffiths: He had had experience of the system now worked at Rome and Milan. At Rome it is altogether alternating; high-tension alternating at Milan—a mixture of three different systems. At Rome, the conducting mains are of wire running

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below the surface. The public and private lighting would be 6,000 or 8,000 lights of 16 c.p., but it is a new thing, and they are putting down engines as rapidly as they can. The public lighting consists of about 20 or 30 lamps. The biggest engine is of 400 h.p. The cost of the lighting is pretty high—considerably higher than that spoken of for London. At Milan they have alternating current used for lighting up two large theatres, they have continuous current on the low tension for most of the incandescent lamps and some arc lamps, and they have also the arc lamp distribution over the whole town, lighting the public streets—high-tension continuous current. Nearly the whole of the arc lamps are used with direct current—either on the low-tension system or on the high-tension system—using the same generating stations, but separate engines and separate dynamos. The station has 14,000 incandescent lamps of 16 c.p., and supplying 350 arc lamps in the streets. The arc lamps were what is called 2 000 c.p.—that is, about 500. They have been using Edison's rigid mains, jointed; but they have introduced largely wire mains. For the arc lamps, however—and only for the arc lamps—they use overhead wires. Coming back to the general question, if they had to light a large house—like Winchester House—with a great number of rooms, it would not be necessary to have more than one transformer under the Metropolitan system in the house. There would be no difficulty whatever with working it with one transformer; but he did not say it would be the best way. He did not like to say what was the greatest load of lamp supply one transformer could safely carry. He did not think any limit had been proved. They had experimented a great deal in America, and the result of their experience was that they do not make transformers larger than 40 lights of 16 candles.

Cross-examined by Mr. Moulton: He had been asked by the Vestry of Paddington to advise them on the subject of electric lighting. The plan which he was proposing that the Paddington Vestry should adopt was to burn their dustbin refuse in properly-designed furnaces to get up steam. The principal difficulty in the way of doing that was that the dust was always coming in during the day, and the burning of it would be all during the night. It was most desirable to get some means of burning the refuse, both day and night, and this was, he might mention, the principal object that made him determine to put down secondary batteries as the first enlargement of the plant, if the plan was gone on with.

Cross-examined by Mr. Wilkins: He did not think any experience had been had with working rigid mains with high-tension current; and to work a rigid main, concentric or otherwise, on a high tension would be an experiment. On the low-tension rigid mains, the joint was always the weak part, and the difficulty of making a secure joint was enormously increased by the tension of the current. He did not think there was any difficulty which could not be got over in connecting the service main with the house from a rigid main, but the chief question was that of insulation. He would not like to make the connection while there was a high-tension current in it.

Examined by Captain Cardew: He would have no objection to putting the secondary to earth in the alternating-current transformers, and he thought it would assist the safe working. If he had absolute control, he thought he could work to a $1\frac{1}{2}$ per cent. variation of pressure. The fact that a concentric main was being used would not increase in any way the danger of making a connection to a house circuit from a distributing main while it was charged; it was not the danger, it was the impossibility. He was aware there were larger transformers in existence than 40-light transformers.

Mr. Alexander Siemens, vice-president of the Institute of Electrical Engineers, was next examined by Mr. Cripps, and deposed that he had had great experience abroad as well as in this country in fixing up electric light installations, including those at Berlin, Moscow, Darmstadt, Munich, and Ebrefeldt. His experience as regarded those cities was that they ran the system now proposed by the Metropolitan Company. In Berlin there were several comparatively small stations, and it was intended to put up a few more, eventually connecting them all in the same way as the existing ones had been connected. In some places there was only one central station where the demand for the light was not very great. The system had been found to work well in Berlin. In St. Petersburg they had a central station with the three-conductor system direct current. In Moscow it was the same. His experience of Darmstadt—they employed a series of batteries in a totally different way from that which was called the E.P.S. system. It was a four-wire system. At Munich it was the three-wire conductor as well as at Eberfeldt. He could not give the exact number of lights there. The pressure through the mains at Berlin was 110 volts. From his experience, considering the condition of London, he was rather inclined to believe that the system in use at Darmstadt, which was a modification of that adopted in Berlin, might best satisfy the wants of London. At the same time, having regard to the long distances, which greatly exceeded those in other places, the transformer system would be as good—that was to say, the transformer system with a number of central stations for generating the current. There would be a saving in cost if they could have the generating centre near the district to be lighted. Five thousand volts was the highest pressure in mains successfully used at Rome. He had made experiments with 10,000 volts. There would be no question of safety in running a pressure of 1,000 volts. If the mains were properly manufactured and laid, there ought to be no leakage.

By Mr. Moulton: In the direct system they could feed into a network at as many points and have as many generating units as they liked, and a constant pressure would be maintained.

Cross-examined by Mr. Shiress Will, **Witness** said that the stations to which he referred were not very far apart—about half a mile. In Berlin they had the two-wire system, which required more copper than the three or four-wire process, which he would not recommend for London. He did not attach much importance to the fact of vibration and noise being a nuisance to the public, because there had been an installation put up and running at the Savoy with 1,200 lights, and nobody had heard it. He did not believe that there had been many complaints made in Berlin.

Cross-examined by Mr. Russell Griffiths, **Witness** said that the object of his experiments with 10,000 volts, which took place at Woolwich, was merely to see what would happen. They had no underground mains to experiment upon. They wanted to see how their machinery would behave in generating such a current.

In reply to Mr. Cripps, he said that if any trouble had been experienced in Berlin it had been overcome.

Sir Wm. Thomson, examined by Mr. A. C. Cripps, said he knew the system which the Metropolitan Company proposed for the supply of electricity to the metropolis—alternating currents and transformers. It was capable, in his opinion, of being used by means of central stations in crowded places. As far as his experience had gone, the highest pressure in vo'ts employed in mains was 2,400—at the Grosvenor Gallery.

Examined by Mr. Graham, he said that he saw the beginning of the works at Deptford, and was familiar with the system by which the London Electric Supply Corporation proposed to bring their electricity to London. It was on the high tension principle. There had been an experience of a pressure up to 2,400 volts. None, so far as he knew, beyond that. He did not think there was an insuperable difficulty in going up to 10,000 volts. It was a very great experiment, being a considerable rise in the voltage, but in dealing with it he thought that electricians had now so much knowledge of the subject, not from practical experience, but from experimental knowledge in the laboratory and from theory, that he did not think there would be any difficulty in going up to 10,000 volts. He did not think there was any insuperable difficulty in properly insulating the mains coming up from Deptford. Any difficulties in laying the mains would, he had no doubt, be successfully overcome. Provided the outer sheath of the mains was well insulated, there would be no leakage to the earth except at Deptford. Provided proper care were exercised by the workmen, there would be no danger to life from such a high potential than there was from a circular saw. For large centra lighting, the reserve power that could be best employed would be to have duplicate engines; for small domestic lighting in isolated places, storage batteries. The direct current was in advance of the alternating current system. He had used it himself in 1881. It was the only one thought of for several years.

Cross-examined by Mr. Moulton: There had no doubt been difficulty in making permanent good joints in underground conductors, but it was not insuperable. Defects in joints did not show themselves at once, but gradually. The seriousness of such defects was, of course, greatly increased by great pressure. In fact, it might be put in this way, that though the circular saw was comparatively safe in the workshop, it was not good in the nursery, and it was exceedingly important to keep high-pressure currents as far away from the consumer as possible. In the direct system, as ordinarily applied, the current was fed at a great number of points into the network. He thought that the best form of reserve power was reserve generating plant. A number of generating units, though not theoretically necessary under practical working conditions, would be of great advantage. For straggling areas there was no doubt that the transformer system was the best.

Cross-examined by Mr. Shiress Will, he said that so far as leakage was concerned the mains could be laid underground as safely as carried overhead. It was a very frequent thing to have two sets of dynamos, one ready to replace the other. He believed that was the system adopted at the Grosvenor Gallery. If the high-voltage dynamos were not well designed, there might be tendency in them to spark.

Cross-examined by Mr. Wallace, he admitted that he had no experience of electric lighting in Germany. He had always been, and was so still, in favour of the direct system with storage batteries for work at a distance. There were advantages in both systems. He took a great interest in the transformer system. He was not practically acquainted with the insulating material to be used for the mains. He had heard it only described. Twelve hours' supply would suffice for a useful storage reserve.

Cross-examined by Mr. Russell Griffiths, he said that he did not anticipate any disturbance to the telegraphic or telephone lines from the high voltage where the outside of the mains was properly insulated. He had not considered what the insulating material should be, but there was no difficulty about that. He thought that an insulation equal to 200 or 300 volts would be amply sufficient for the high-tension mains.

Examined by Captain Cardew, he said that he would recommend the earthing at the Deptford end and earthing of the supply wire in every house one of the two supply low-tension mains in every house.

Re-examined by Mr. Graham, he said that he knew of no difficulty that could not be overcome with proper insulation. His opinion had grown up in favour of the transformer system.

Mr. J. S. Balfour, M.P., a director of the Metropolitan Supply Company, was examined by Mr. Lyttleton, and said that he believed the subscribed capital of the company was sufficient for their present purposes. He thought that there might be extensions of the company's undertaking in the future, in which case there would be no difficulty experienced in raising as much money as might be required to carry them out. He was a considerable owner of property in South London, from which there were a large number of applications for the light. Their original £500,000 capital was over applied for, and there would be no difficulty in getting a million if they wished to raise it.

In reply to Mr. Wallace, he said that the public subscribed their capital on the faith of the companies' getting the provisional order they applied for, which was alluded to in the prospectus. He had not entered into any agreement with the House-to-House Supply Company, nor was it likely that such an agreement would be entered into.

Cross-examined by Mr. Moulton, he said that they had not entered into any agreement with the Strand Board of Works. There had been some negotiations, but nothing definite had been decided on.

(*To be continued.*)

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COMPANIES' MEETINGS.

ORIENTAL TELEPHONE COMPANY.

The ninth ordinary annual general meeting of this Company was held on Tuesday at the City Terminus Hotel, Cannon-street, Mr. William Addison in the chair.

The **Chairman** congratulated the shareholders on the position of the Company. Each year they had been doing better. The Directors recommended smaller dividends than might otherwise have been declared for the purpose of enabling them to form a reserve fund, which would be easily realised, if necessary, and enable them to extend the business of the Company without calling upon the shareholders for more money. They proposed to place £2,500 to the reserve fund, to apply £3,000 in final extinction of preliminary expenses, and to write off £341. 4s. 8d. for depreciation of stores and the balance of the cost of the reconstruction of the Rangoon exchange, besides paying a dividend of 3 per cent., free of income tax, on the paid-up capital of the Company other than vendors' shares, and carrying forward £685. 18s. 11d. He proposed the adoption of the report and balance-sheet.

Mr. Cavendish Bentinck seconded.

Mr. Power said he objected, as a large shareholder, to a dividend of 3 per cent. only when 5 per cent. had been earned. He could not see any reason for putting so much to a reserve fund, particularly after waiting for nine years.

The **Chairman** said it was understood in the outset that the Directors would endeavour to carry on the business of the Company without making another call on the shareholders. They wished to extend their business at the most convenient opportunity, and they could not do so unless they had a reserve fund.

The report was adopted, after two "counts," by 18 to 17.

A 3 per cent. dividend was then agreed to, and Mr. Henry Growing and Mr. Thomas Lloyd were re-elected Directors.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the past week amounted to £3,407.

Western and Brazilian Telegraph Company, Limited.—The receipts for the past week, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £2,171.

Personal.—We are requested by Mr. Slater Lewis to state that he has resigned the managing directorship of the Telegraph Manufacturing Company, and that all correspondence intended for him should be addressed to his private house at Helsby, near Warrington.

Indo-European Telegraph Company, Limited.—The report of the Directors of this Company for 1888 states that the Board express deep regret at the retirement from the chair, after an occupancy of 17 years, of Colonel James Holland, and their satisfaction at the acceptance of that office by the present chairman, Mr. J. Herbert Tritton. The Company's revenue from all sources for 1888 amounted to £110,327, as compared with £104,291 for 1887. The expenses were—on commercial and general account, £28,610; on maintenance account, £23,783—total, £52,393, as against £48,621. Deducting the above expenses, taking credit for £2,695, brought over from 1887, and debiting income tax, there remains the sum of £59,284. From this amount £10,000 has been placed to reserve, and that sum, together with £10,625, amount of interim dividend, has to be deducted, leaving a balance of £38,659. The Directors now propose the declaration of a dividend for the last six months of 17s. 6d. per share, making, with the interim dividend already paid, 6 per cent. for the year, and a bonus of 20s. per share, both free of income-tax, making in all 10 per cent. for the year, carrying forward £6,784 to the credit of 1889.

PROVISIONAL PATENTS, 1889.

APRIL 8.

5955. **Improved ceiling rose or connector for electrical circuits and for the suspension of electrical fittings.** Edward William Lancaster, Albert Works, Graham-street, Birmingham.

6005. **Improvements in carbon contacts or commutator brushes.** Charles Joseph Van Depoele, 6, Lord-street, Liverpool. (Complete specification.) (Date applied for under Section 103 of the Patents Act, 1883, 7th September, 1888, being date of application in the United States.)

6007. **Improvements in the construction of electric brushes for curative purposes.** Mary McMullin, 8, Quality-court, London.

6013. **Improvements in wire or cable-uncoiling and wire or cable-straining apparatus.** Edgar Howell Rex Evans, 55 and 56, Chancery-lane, London.

6021. **Improvements relating to dynamo-electric machines and electric motors.** Alfred Lyster Shepard, 45, Southampton-buildings, London.

APRIL 9.

6033. **Improvements in the art of transmitting articulated speech by the agency of electricity, without employing pulsatory, undulatory, or vibratory electric currents on the line.** John Absterdam, 52, Chancery-lane, London. (Complete specification.)

6063. **Improvements in and relating to safety-devices for electric circuits.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) Complete specification.)

6064. **Improvements relating to electro-magnets and to armatures for dynamo-electric machines or electric motors.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) (Complete specification.)

6065. **Improvements in and relating to electric motors.** Henry Harris Lake, 45, Southampton-buildings, London. (Elihu Thomson, United States.) (Complete specification.)

6078. **Improvements in electric arc lamps.** Ferdinand Auguste Gobert, 3, Deronda-road, Herne Hill, London. (Complete specification.)

6104. **Improvements in the manufacture of filaments for incandescent electric lamps.** Henry Harris Lake, 45, Southampton-buildings, London. (J. B. Tibbits, United States.)

6112. **Improvements in secondary batteries.** Philip Arthur Newton, 6, Bream's-buildings, Chancery-lane, Middlesex. (Wm. Main, United States.) (Complete specification.)

6119. **Improvements in thermo-electric batteries.** James John Shedlock and Richard Mestern, 9, Gracechurch-street, London. (Complete specification.)

APRIL 10.

6171. **Improvements in means for regulating or controlling electric currents.** Charles Richards Heap, 47, Lincoln's-inn-fields, London.

APRIL 11.

6195. **Improved method of and means for constructing globes for incandescence electric lamps.** George Houghton Shepherd, 4, Little Moorfields.

6209. **An improved exciting liquid for use in electric batteries.** Eduard Liebert, 45, Southampton-buildings, London.

APRIL 12.

6231. **Improvements in apparatus for producing electro-magnetic action with small self and mutual induction.** William Edward Ayrton, 2, Upper Phillimore-gardens, John Perry, 10, Penywern-road, London, and Edward Wythe Smith, 66, College-street, Chelsea.

6284. **Improvements in electric cut-outs.** Herbert Napier Prentice, 47, Lincoln's-inn-fields, London.

6285. **Improvements in dynamo electric machines and electric motors.** Herbert Napier Prentice, 47, Lincoln's-inn-fields, London.

6286. **Improvements in secondary batteries.** David Urquhart and William Bates, 11, Victoria-street, Westminster.

APRIL 13.

6332. **Improvements in connection with electric fuses.** William Harding Scott and Laurence, Paris, and Scott, Limited, Gothic Works, King-street, Norwich.

6384. **Improvements in and relating to electric switches.** Albert Augustus Goldston, 4, South-street, Finsbury, London.

SPECIFICATIONS PUBLISHED.

1888.

4626. **Electrolytic production of metals.** Hoepfner. 6d.
4819. **Electro-medical battery.** Johnson. 8d.
4844. **Electric lamps.** Thompson (Garczynski.) 8d.
5640. **Distributing, &c., electricity.** Edmunds. 8d.
5848. **Electrical operations at intervals.** Edmunds. 8d.
6627. **Electric lamp, &c.** Tabourin. 8d.
6836. **Electro-dynamic relay.** Ayrton and others. 6d.
7308. **Electric date, &c., stamp.** Randall. 8d.
7522. **Electric switch.** Houghton. 8d.
7548. **Floating telegraph station.** Dieudeveult. 8d.
7750. **Electric arc lamps.** Dulait. 8d.
13779. **Telephone sub-station apparatus.** Vail and Seely. 8d.

1889.

2949. **Galvanic batteries.** Cross. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday.
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¼
12 Feb.	2/0	— fully paid	5	4¼
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	17¾
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply ...	5	4½
......	...	Swan United	3½	2½
12 July	12/0	Telegraph Construction ...	12	42
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	16½

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NOTES.

Carlsruhe.—This town is to have a central station.

Italian Telegraphs.—The King of Italy has signed a decree providing for the appointment of a Minister of Posts and Telegraphs.

The Telephone in Holland.—The Dutch Minister of Public Works is about to bring forward a measure for the reorganisation of the telephone system in Holland.

Society of Arts.—A paper will be read by Mr. W. H. Preece, F.R.S., on "Secondary Batteries," before the Society of Arts on Wednesday next, May 1, at 8 p.m.

Belgium.—Public tenders will be received up to May 2 for electric light at the railway station at Meirelbeke, and at the central railway works at Gendbrugge, Belgium.

Helsby.—We are informed by the Telegraph Manufacturing Company, Limited, Helsby, that Mr. J. Slater Lewis has resigned his position as managing director, and has no longer any connection with or interest in the company.

Brush Lamps and the Paris Exhibition.—The Anglo-American Brush Corporation have been compelled to withdraw their application for share at the Paris Exhibition, their works being too busy to complete exhibits in time.

"Continued."—The gas companies at Metz and Venice have applied for powers to establish central stations for lighting by electricity. At the end of this month the last remaining gas jets in the Palais Royal, Paris, will be removed.

Brussels.—As will be seen from an advertisement in another column, the Administration Communale of Brussels have decided to invite tenders from English firms for the public city lighting. The tenders are to be sent in before July 1.

Telephone v. Telegraph.—The long-distance telephone is running the telegraph hard already in news items. At the Birmingham election the result was reported in Sheffield by the National Telephone Company, according to the *Sheffield Independent*, seven minutes before the telegraph.

Overhead Wires in New York.—Owing to the removal, by order of the mayor, of the overhead electric wires in New York, Madison and Union squares and the immediate vicinity were left in darkness on Wednesday, the 17th inst. The cutting of telegraph wires and poles has been continued.

Personal.—We are informed that Mr. Swinburne has entered into partnership with the Earl Russell and Mr. H. S. Holt. Messrs. Swinburne and Co. have temporary premises at Teddington, where they will carry on general electrical engineering. Mr. Swinburne's consultation address is 49, Queen's-road, Wimbledon.

Telegraphs between France and China.—The conclusion of the telegraphic contract between France and China on the Tonquin frontier has now been definitely settled. By this arrangement a wire will be laid down between Langson and Langchow, the capital of Kwangsi—50 miles from each other—and direct telegraphic communication will then be established between Saigon and Pekin.

North German Steamers.—The new steamship, "Munchen," built for the North German Lloyd, for service to South America, is fitted with 300 incandescent lamps. These are supplied by two dynamos—one being for reserve—each of 250 amperes and 100 volts, running at 360 revolutions. The dynamos were supplied by Siemens and Halske, and the engines by Daevel and Co., of Kiel.

Paris.—At the meeting of the Municipal Council of Paris, held on the 17th inst., a concession was granted to MM. Nouvelle and Geisenberger for the lighting of a section of the left bank of the Seine. The section extends to the fortification in one direction, and is bounded by the Rues Saint-Jacques and Tombe-Issoire, and the Rues des Saints-Pères, du Cherche-Midi, and des Fourneaux in other directions.

The Northfleet Electric Tramway.—We are pleased to hear that the Series Electrical Traction Syndicate, Limited, have now received from the Board of Trade a certificate that their electrical tramway at Northfleet has passed the Government inspection, and a license to use electricity as the motive power thereon for seven years. The line will in consequence be opened to the public immediately after the Easter holidays.

Tenders for Roumania.—The town of Craïova, Roumania, is to be lighted by electric light, and tenders will be received from the 1st to 13th June next. Tenders must be addressed to the Engineer (Bureau technique) at the Mayor's office, and must be accompanied with a deposit of 5,000 francs. Contractors must specify (1) the system employed, (2) the price per lamp, (3) the number of years for which the concession is asked.

Electric Lighting in the Inner Temple.—The elaborate preparations made some time since for the purpose of illuminating the chambers and offices in the Inner Temple generally with the electric light have now been definitely abandoned, and the extensive excavations made in the Inner Temple-gardens for the reception of the plant and machinery necessary for the purpose are now being filled in, and the gardens will shortly resume their usual appearance.

A Projected New Transatlantic Cable.—Advices from Barcelona state that a syndicate of commercial men has applied for the Government sanction to lay a cable from the coast of Spain to the Spanish Antilles. As there are already in existence cables from Cadiz to the Canary Islands, and from Cienfuegos to Santiago de Cuba, it is proposed to take advantage of these, and to lay new cables to connect the Canaries with Porto-Rico and the latter place with Santiago.

Water Switches.—M. Marcel Deprez has recently patented some new types of resistances and switches for use with high-tension currents, such as for the transmission of force. In these he uses pure water as the connection, and the metals themselves never touching, there is no spark on breaking contact. Pure water is preferred for high-tension currents, acidulated or salt water is only used for currents of low tension and large quantity. The contacts can be made of ordinary iron or lead.

The Telephone Amalgamation.—The arrangements for the proposed telephone amalgamation throughout England have been unexpectedly pulled up by the refusal of the Postmaster-General to consent to the proposal. No transfer of license can be made without his consent, and the telephone companies are therefore at a standstill. The

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idea that the Government may have to buy up the companies is supposed to be at the bottom of this move, the value of the system, if amalgamated, being greatly increased.

Folkestone.—With reference to the contract for lighting Folkestone by electricity, one of the gas journals remarks that, although the scheme has passed the Council, and has been practically signed and sealed by them, there still remains a difficulty with the gas company, as their agreement with the Corporation does not expire until July, 1890. Unless they are willing to allow the agreement to be cancelled, with fair compensation, Messrs. Crompton's contract, thinks our contemporary, will either have to be delayed or will become invalid.

The C & C Motor.—We understand that Messrs. Gwyne, the eminent engineers, after a careful trial of various motors, have decided to use the C & C motors in connection with their ventilating fans and their new system of ship ventilation. A second order for 50 of these motors, in various sizes, from 3 h.p. downwards, has been given to Messrs. Shippey Bros., the agents for these motors in England. It may also be interesting to know that a large number of these motors will be used in the Paris Exhibition for driving various exhibits.

Electric Power in Russia.—The following communication from a correspondent in Russia has an interest peculiarly its own. Referring to the "Memoires sur l'application d'électro magnétisme au mouvement des machines," our correspondent remarks: ϽТО СОуNНеНІе ООраТNАО На НЕ̄ІО ВНNМаНІе, N еМу ОbІАО ІІреАОсТаВАеНО Вb КӧНNꞁсОерꞁВ МВсТО ꞁраꞁКАаНсКаꞁО N НꞁКо Нера." We are glad to hear of this point in Russian practice, but with regard to the КӧНNꞁсОерꞁВ, we think it is exceedingly likely it has already been attempted in England.

Electricity in Mines.—Incandescent lights now light up the underground workings of the Anaconda Mine, Montana, U.S. They started off with 500 lamps, but more are constantly being added, and soon 1,000 lights will be in use. Candles are a thing of the past in that mine. Electric lights will also be used in the hoisting works, blacksmith shops, and all shops and buildings about the mine. The mining superintendent says the electric lamps are better, cheaper, and safer than candles. The cost of the whole plant, engines and all, is £5,000.

Importations from America.—The importation of American plant continues to increase in rapidity and importance. It may have been noticed that the s.s. "Erin," "Holland," "Umbria," etc., have brought during the last month nearly a hundred cases of electrical goods, consisting of motors, secondary batteries, to the orders of Messrs. Shippey Bros., and various installations throughout the country, while Westinghouse, Thomson-Houston, Woodward Electrical Company, and others, are shipping largely. It seems that the Americans mean to do as large a business in England in electrical apparatus as they do in the States.

Another Claimant.—We notice in our esteemed contemporary, the *Western Electrician* of Chicago, that there is another claimant (Mr. Freeman) to the honour of inventing the incandescent lamp. It would be interesting to know what Mr. Freeman's claims actually are, and in what respect these claims differ from those of Mr. Woodward, whose invention was patented in Canada in 1874, and in the United States in 1876, which invention describes the carbon, and also claims the parallel system of subdivision. It may be here remarked that Mr. Woodward is an Englishman, born at Birmingham; therefore we must still claim this invention for an Englishman, although the patent, we believe, is controlled by the Edison Company of the States.

Electric Communication for Prisoners.—In accordance with the order of quarter session, electric communication has been established between the police office and the five cells reserved for prisoners at the Shire Hall, Chelmsford. In each cell there is the usual electric button, which on being pressed rings a bell in the office. By an arrangement of discs the officer in charge can see from which cell the call comes, and underneath there is a switch to disconnect, if the prisoner be unruly and keep on ringing. The accommodation is, of course, for prisoners who are ill or who want to see the police for any other reason. The appliance has been supplied by Mr. Stapleton, of Chelmsford.

"Calais-Douvres."—It has been decided to call the new mail steamer of the London, Chatham, and Dover Company the "Calais-Douvres," and the old twin-ship of that name will be withdrawn. The new ship is built wholly of steel, and divided into nine watertight compartments, and is designed to be as safe as engineering skill can make her. She is fitted with very powerful engines, and is expected to make the trip from Dover to Calais within the hour. The vessel is being luxuriously fitted up, and will have, in addition to a fine deckhouse and state saloon a number of private cabins. The lighting will be done throughout by incandescent electric lamps, and powerful arc lights will be fitted for embarkation purposes.

Callender's Bitumen Telegraph and Waterproof Company, Limited.—The annual meeting of this company was held at its offices, 101, Leadenhall-street, on Wednesday, April 17, at 12 o'clock, Sir George R. Prescott, Bart., chairman of the Board of Directors, presiding. A most satisfactory report of the year's working was presented, showing a very large increase of business during 1888, and a dividend on the ordinary shares was declared, a substantial sum being also carried forward to the reserve fund. Sir G. R. Prescott and Mr. Henry Drake were re-elected directors, and the proceedings, which were unanimous throughout, terminated with a cordial vote of thanks to the directors and officers of the company.

Electrical Flaw Detector.—The recent accident at Penistone was thought to be due to a defective crank axle, and Major Marindin, in a recent report, mentions a similar case which occurred on the North Staffordshire Railway, when three passengers were injured slightly. The crank pin of the engine failed, and on an examination the fracture showed a very bad old flaw, extending so far into the metal that it left sound only a strip of $\frac{1}{8}$in. in width along the diameter of the pin. Major Marindin points out in justification of the railway companies that it would be quite impossible to detect a flaw inside the axle by any known method of examination, however careful, and he suggests that if such flaws in inaccessible positions could be detected by some electrical contrivance the invention would be a most valuable one.

Celluloid Slide Rules.—Slide rules are now a *sine qua non* to engineers having to undertake long and extensive calculations. A new slide rule of improved construction has been brought out by Messrs. J. Davis and Sons, of Derby, and 118, Newgate-street. The body of the rule

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is of wood, in which strips of hard white celluloid are inlaid, and on these celluloid strips the scales are engraved, being thus in black lines on a white ground. The advantages claimed are greater accuracy, together with greater clearness of reading; it wears well, and does not become discoloured; and also the markings remain unchanged, or rather without relative change, from variation of temperature. The rule is of the Gravet type, 10in. long, and should prove exceedingly useful to those who use, or who, hereafter, learn to use, the slide rule for their calculations.

Electric Fountains at the Paris Exhibition.—It seems to have been happily decided, says a correspondent of the *Times*, to make the main buildings of the Paris Exhibition permanent structures—namely, the parallel wings, with their graceful domes, and the machinery gallery, which is exactly the size of the Place Vendôme. A large fountain, to be lit up with electricity, is now being arranged on the model of that at South Kensington as improved upon at Barcelona. Another fountain under the Eiffel Tower will fill the void left by its huge compass-like legs. This also will be lit up, but less elaborately. In 1878 the Industrial Exhibition was in the centre, and all the ornamental and amusing parts were grouped round it. This time the refreshment places, concert-rooms, shows, and gardens will be incorporated, as it were, in the exhibition, thus giving it much greater liveliness. Even in the unfinished condition of the opening day a lively idea will be formed of the attractions of this world's fair.

As She is Writ!—As our readers are aware, the Portuguese are nothing if not authoritative. When we wish to obtain really accurate information we should consult the Lisbon press. We don't, but that is probably owing to our insular prejudice. The following ray of intelligence has been shot across the waste of Biscay from the offices of the *Commercio de Portugal*. It arrived in a damaged condition, probably having struck a fog bank on the way. After describing the arrival at Mossamedes of the English steamer "Amberde," commanded by Mr. Robert Gray, our Portuguese contemporary goes on to say that this vessel at once proceeded to carry out the soundings for the new cable of the "Companhia telegranhica Easter-nand Shout Africam (*sic*) Telegraph C.ª" We thought we knew as much as most people about telegraph companies, and yet if it had not been for the happy chance that threw *O Commercio* in our way we should probably have omitted to notice this new organisation. We wonder what it is they "shout?"

The Lineff Electric Tramcar System at Acton.—Before the Acton Local Board, last week, a letter was read from Mr. E. H. Bayley, on behalf of the Lineff Electric Traction Company, stating this company were most anxious to proceed with the work, and the two jobs of doubling the line (which was before the Board) and laying the electric conductor must be done, if at all, at the same time. Some considerable discussion ensued, and in the end it was agreed, on the proposition of Mr. Blake, seconded by Mr. Miller, that a deposit of £500 be demanded from the company, and also that the company pay the legal expenses incurred in obtaining the mandamus against them, and, further, that a fresh plan must be submitted showing exactly what was approved by the Works Committee. The Works Committee had on their list of recommendations that the plans of the West Metropolitan Tramway Company for doubling the line be approved, and that the Lineff Electric Traction Syndicate be allowed to work the tramway by electricity, but before passing their report these recommendations were withdrawn.

Too Late.—It would serve no useful purpose on our part to delay the expression of an opinion as to the immense loss that has been sustained to the historian of cable work by the death of Mr. Newall. The editor of this paper, who, as is well known, was from its first number till October, 1887, connected with another paper in a similar capacity, was very desirous of obtaining Mr. Newall's recollections about the early history of cable work, and had made arrangements with Mr. Newall to do so. Mr. Newall stated that much of the published information was incorrect. Our contemporary, *supposed* to be run for the benefit of the cable companies and cable workers, and largely paid for by the shareholders of the cable companies in order to support their interests, seems to be absolutely ignorant of the value of any information either relating to cable history or cable work. It is allowing the old workers to die off without obtaining the facts relating to the part they played in the work. But, perhaps, the only thing worth doing in connection with cable work is the reporting at length the sayings and doings of those who control the cable system now. That is a happy state of things and easily done.

Electric Light at the Mysore Palace.—"The Maharajah's palace at Mysore," says the *Indian Engineer*, "is soon to be lighted throughout with electric lights. Every room, hall, nook, and corner will be adorned with these lamps. The first storey of the palace will contain 62 lamps, and the second 120. They are all said to be incandescent lamps of 16 c.p. each, with shade over and a small globe underneath. The palace will be also lit with six arc lamps of 2,000 c.p. each, while at the very top of the palace will be the largest projector lamp in India, of 5,000 c.p., which is intended to throw a light from 60 to 80 miles distance, and throw a shadow which, if thrown up, will be seen at Madras, Ootacamund, etc. The working will be arranged with a current from 53 accumulators, which will be charged by the machines, for which the engine will work once for a certain number of hours every alternate day. The wires have been placed all over the palace with much ingenuity and skill by Mr. Charrington, the electrical engineer, and his assistant, Mr. George Hardaker. The arrangement of lighting by electricity has been calculated to be a saving to the exchequer."

The Electro-Harmonic Society.—The last smoking concert of the season takes place to-night (Friday) at the St. James' Hall Restaurant (banquet-room) at 8 o'clock, when the following programme will be carried out: Part I. Terzetto, "Che fate qui, Signor!" (*Faust*) (Gounod), Mr. William Nicholl, Mr. Arthur Thompson, and Mr. B. H. Grove; violin duet, "Symphonie Concertante" (C. Dancla), M. Greebe and Mr. T. E. Gatehouse; song, "Venetian Song" (Tosti), Mr. William Nicholl; solo pianoforte, Mr. Alfred Izard; song, "Vulcan's Song" (Gounod), Mr. B. H. Grove; solo violin, "Fantaisie Caprice" (Vieuxtemps), Mr. T. E. Gatehouse; musical sketch, "A Children's Party," Mr. Dudley Causton. Part II: Duet, "Sui campo della gloria" (Donizetti), Mr. W. Nicholl and Mr. B. H. Grove; songs, "To Chloe" and "Maiden Mine" (Sterndale Bennett), Mr. Arthur Thompson; violin duet, "Introduction and Rondo" (Kalliwoda) (by desire), M. Greebe and Mr. T. E. Gatehouse; song, "Kathleen Mavourneen" (Crouch), Mr. William Nicholl; trio, "Winds gently whisper" (Whittaker), Mr. W. Nicholl, Mr. A. Thompson,

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and Mr. B. H. Grove; musical sketch, "Penny Reading Oddities," Mr. Dudley Causton.

Electric Tanning.—Not content with the treatment of sewage, electrical engineers ever seek "fresh woods and pastures new," if we may so describe such unsavoury manufactures. This time it is the tanning of leather hides, the objectionable nature of which is not much less than that of the first-mentioned process. The process of electrical tanning (Worms and Balé's patent, No. 9,515, 1887) appears to have been carried on for some six months at full work in France by the Société Française de Tannage, who turn out leather of the best quality. Some special harness for the Paris Exhibition is to be made of leather so treated. The process consists of subjecting the hides in contact with ordinary tanning materials (without acids) to the action of a current of electricity on a revolving drum. The saving in time is very great—two to four days instead of three to nine months—while the cost is reduced to 1¾d. or 2d. instead of 4d. A company under the name of the British Tanning Company, Limited, 17, Basinghall-street, has been formed to work the process in this country, of which several prominent tanners and Mr. William Crookes, F.R.S., are directors. The process, as carried on in France, has been favourably reported on by practical leather tanners and by Prof. Silvanus Thompson, who found the electrical arrangement well conceived and carried out in a practical manner.

Congress of Applied Mechanics at Paris.—There will be held at Paris, at the Conservatoire des Arts et Métiers, an International Congress of Applied Mechanics, under the patronage of a Committee of Honour, comprising savants and engineers of renown both from France and from other countries, who will give the work of the congress the benefit of their influence and the weight of their authorities. The President of the Committee on Organisation is Mr. Phillips, ex-inspector general of mines (retired). The five members appointed from the United States are, in the order of their mention on the official bulletin, Messrs. Robert Grimshaw (president Polytechnic Section Am. Institute, N.Y.), R. H. Thurston (director, Sibley College of Cornell University, Ithaca), Prof. Egleston (Columbia College School of Mines, N.Y.), and the Presidents of the American Societies of Civil and of Mechanical Engineers. At this congress, among the important subjects submitted for discussion are the unification of the horse-power, the choice of materials in machine construction, the mechanical production and utilisation of artificial cold, transmission to a distance, and distribution of work, by other means than electricity (water, air, steam cables, etc.), automatic cut-off engines with several successive cylinders; thermo-motors other than the steam-engine. Other topics, treated by papers, will be improvements in steam-engines since 1878, progress among associations of owners of steam appliances, and improvements in apparatus for the generation of steam, more particularly sectional boilers.

A New Motor.—We are indebted for the following to our excellent contemporary, *Industries*: "'Sir,—We have pleasure in informing you that we have succeeded in constructing an alternating-current electric motor which, especially in point of efficiency, is in no way inferior to the most perfect continuous-current motors. The enclosure contains particulars of this motor and the experiments made with it, and we place it at your disposal for publication in your esteemed journal.—Yours, etc., GANZ & Co., Budapest, April 10, 1889.'

[The enclosure to which Messrs. Ganz and Co. refer in the above letter does not contain a technical description of the motor, but merely some general remarks on the importance of utilising alternate currents for the production of motive power, coupled with a statement that hitherto this problem has not received a solution. As far as may be judged from the general tone of their remarks, it would appear that in their new motor the armature is at rest, and only one circuit is required. They give the following table of results obtained with an experimental motor which having been worked at a slower speed than that for which it had been designed (750 revolutions per minute), is expected to give when running at full speed even a higher efficiency than that obtained in the trials:

Revs. per minute.	Power developed.		Energy apparently supplied. Watts.	Actual energy supplied.		Ratio between apparent and actual energy.	Commercial efficiency per cent.
	H.P.	Watts.		H.P.	Watts.		
600	15·0	11,000	18,000	21·5	15,800	·88	77·0
700	19·8	14,600	24,200	25·2	18,600	·77	78·5
730	30·7	22,400	29,800	37·6	27,700	·92	80·9

The subject of an alternate current motor requiring one circuit only, capable of starting under a load, and having a fairly high efficiency, is of so much importance to the electrical industries generally, that we make no apology for placing the statements emanating from the Budapest firm before our readers as they were made to us.—ED. *Industries*.]"

The Distribution of Power by Electricity.—The new American journal *Electric Power*, which we have already welcomed into the ranks of technical papers, sounds the note which we have continuously advocated with regard to the distribution of power. It says: "It is useless to attempt to disguise the fact that a large proportion of the local electric lighting companies in the United States fail to return a sufficient margin of profit to entitle them to recognition as first-class business investments. There are various causes for the existence of this state of affairs. Some of the earlier companies were loaded down with the burden of expensive plants, others were handicapped with wasteful or unreliable apparatus. Many have been the victims of mismanagement by the installation of favourite sons as prime movers. Of late years, competition has tended toward the cutting of rates, and has not as yet reached that culminating point where the lamb has lain down inside of the lion. It is well understood that the business of arc lighting soon reaches its limit. Its field is of slow growth, and increased earnings must be sought either in incandescent lighting or the supply of power. Intelligent managers are rapidly being convinced that the power business should not be neglected, and are turning their attention to its eventual development. The obstacle in most instances appears to be that arc systems being most generally used, they are not deemed available for power purposes on account of the danger attending the handling of motors by inexperienced persons. It is perfectly practicable to guard against accidents, provided a competent engineer supervises the installation. The distribution of power, however, is not equally available as a source of revenue in every town, while light from some source is an absolute necessity wherever human beings congregate. What is needed is continual study of the various conditions. Every person should make it a

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point to note every possible opportunity where electric power can be successfully applied. It must always be borne in mind, however, that if a contract is undertaken, the work must be so done that it will reflect credit on the general interests of the business."

Changes in Copper Wires.—In an abstract given in the *Journal* of the Institution of Electrical Engineers of a paper by M. F. Larroque, on the "Permanent Changes Produced in Copper Wires by the Passage of a Current," in *La Lumière Electrique*, we note the following: "It has been noticed since a long time that the continued passage of a current of electricity in a copper wire tends to render it brittle. Dufour noticed a decrease of more than 30 per cent. in the tensile strength of a copper wire which was traversed by a current insufficient to heat it sensibly. Wertheim thought that he had found that the decrease in the tensile strength was only temporary, and disappeared when the current was interrupted. Edlund and Streintz speak of a permanent elongation, but the experiments of Blondlot have demonstrated that this is an error. So long as the small currents chiefly used in telegraphy were the only ones to be considered, their effect on their conductors was not of practical importance; but with the spread of the sphere of electricity for lighting and transmission of power, and the more general use of heavy currents for these purposes, the permanent effects produced by them in copper wires claim attention. The breaking of an old electric light cable led the author to investigate the question. A piece of a wire used during twenty years to convey the current to a lighthouse could be easily broken up with a hammer; the broken surfaces showed clearly that the metal had a granular structure, such as is seen in copper deposited electrolytically, although when first put up the wire had been hard-drawn. Owing to the section of the conductor, it probably became somewhat heated by the passage of the normal current, though the rise of temperature could scarcely have exceeded 30deg. or 40deg. It seems that the long-continued passage of a current of electricity tends to bring about a molecular rearrangement, resulting in a granular structure. Moreover, as far as experience goes, it seems to be immaterial whether the current is direct or alternating, as the action of both is similar. The secondary of an induction-coil had become so brittle from long use that the wire could not be unwound, but broke repeatedly. The ratio of the resistance of the old wire to that of a new wire of similar length and diameter was found to be as 21 to 16. From his own experiments, which were carried out with spirals and zigzags of copper strip, the author concludes—(1) That the elongations referred to are excessively small, and do not follow any definite law. The lengthenings and shortenings probably result from want of homogeneity, and are not permanent results produced by the passage of the current. (2) That the changes in the tensile strength depend on the strength of the current traversing the conductors, but the relation is not one of simple proportion; the passage of the current has more effect on hard-drawn copper than on annealed copper; alternating currents seem to act more quickly than direct currents. (3) A current of two amperes, especially when alternating, materially changed the elasticity of a copper wire 3mm. in diameter, after a lapse of four years. It would certainly seem, therefore, that conductors carrying heavy currents such as are used in electric lighting are fated to undergo a kind of slow disintegration which will affect not only their tensile strength, but also their resistance."

A Telegraph which Produces a Printed Sheet. The tape telegraph or "ticker" now so common at clubs and brokers' offices is practically doomed, and "flimsy"—the written messages sent out from the telegraphic news offices—is likewise soon to be a thing of the past, by reason of the practical introduction on a large scale of the new type-writing telegraph of Messrs. Moore and Wright in the offices of the Central News Agency at Ludgate-hill. This instrument has been practically tested for some little time past, and we had recently an opportunity of inspecting the instrument at work, and of ascertaining what is its scope, and what is intended to be done with it. The instrument, indeed, fulfils a "long-felt want." The origin of the invention has been, as a matter of fact, the constant complaint from newspaper men of the difficulty of dealing quickly and easily with the news as now delivered. Either it comes in strips, which have to be cut up and pasted together; or it comes in "flimsy," and is liable to tear and smudge when sent up to the compositors. Messrs. Moore and Wright, who are connected with the Central News Agency, therefore, some eighteen months ago started to construct a telegraph which would print its message in lines on a sheet instead of a strip. This instrument they have perfected, and are intending to fit them up in the offices of their subscribers—the newspapers and clubs of London—to the number of some 220, as soon as they can be got ready. The instrument is in reality an electric typewriter, but having one keyboard and any number of sets of typewriters. The keyboard, at present, is arranged like an A B C telegraph, but it has only to be fitted with a keyboard similar to the ordinary typewriter for anyone used to the latter instrument to be able to work the transmitter. The receiver has a type-wheel, controlled by an electromagnet in the same way as the usual tape telegraph, but at every letter the type-wheel is pushed one space along the shaft. The motion of the type-wheel is actuated by a train of wheels, and a second magnet and train of wheels can be brought into play at the end of the line, which causes in one motion the paper to be pushed up and the type-wheel to go back to the beginning of the line. The appearance of the message, printed on a broad coil of paper, is exactly similar to that of an ordinary type-written message, and is, therefore, of great superiority to the tape for news items, or notices for exhibition in clubs, while quotations for stocks and shares can thus be printed in columns for use at once. The receiver is quite as ingenious as the transmitter. A small electromotor revolves, by means of a lightly-resting friction-wheel, a reversing electric contact. This keeps the magnet of the receiver constantly vibrating. As the button belonging to each letter or sign is depressed, this revolving contact is stopped at the letter, and the type, at the receiver end, is struck on the paper. At the end of the line a slightly stronger current is sent by momentarily cutting out a resistance, and then by another button the circuit is opened. The result of the first is to excite the auxiliary magnet of the receiver, which attracts a catch on a pinion, while opening the circuit releases the catch. The second train of wheels comes into operation, shifting the paper and the type-wheel at the same time to begin a new line. The receiver costs about £19, but it is not intended to sell them, but to hire them out in the usual manner as with tape instruments. The Central News Agency will put down a gas-engine and accumulator to work the series of instruments from Ludgate-hill, and it is expected that they will be ready to work about August.

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MAQUAIRE'S "ALPHA" ARC LAMP.

It will be remembered that at Prof. Silvanus Thompson's lecture at the Society of Arts special mention was made of a new arc lamp, exhibited then for the first time publicly in England, in which the feeding of the carbons was actuated by the motion of a small reversing electric motor in the mechanism. This was Maquaire's patent "Alpha" arc lamp, which, in distinction to other types, was classed under the head of the "electrical engineers lamp." Both the detent action and the mechanical motion of feed are controlled electrically, and the feeding is thus directly dependent of the needs of the lamps, the carbons being fed by imperceptible movements, and only when the electrical requirements of the arc itself need the feeding. The running of this lamp is certainly remarkably steady, and it has very good claims to become one of the leading arc lamps of the future.

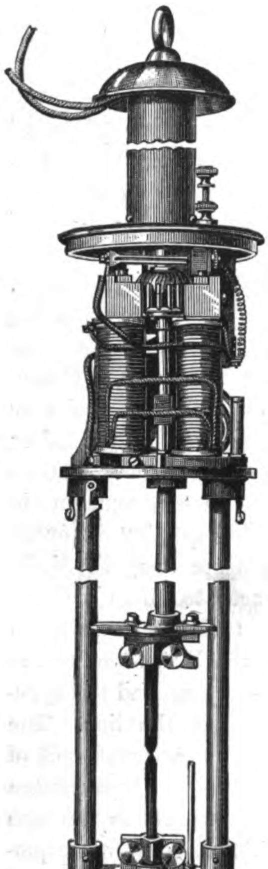

Fig. 1.

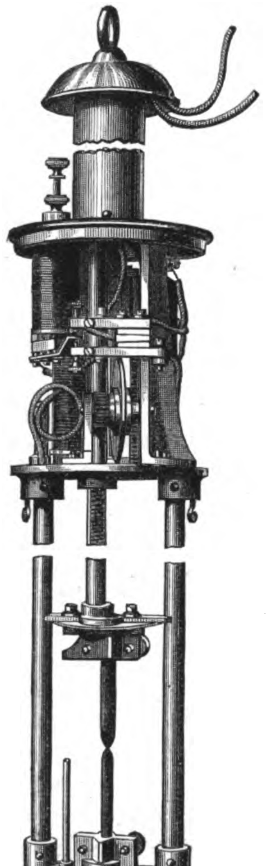

Fig. 2.

We are now able to give illustrations and description of this lamp, from which it will be seen that the new conditions have been worked out with considerable ingenuity. Fig. 1 is the "Alpha" arc lamp with casing removed, showing the small electromotor and brushes. Fig. 2 shows the regulating mechanism. Fig. 3 is a diagram of the connections.

To understand exactly the action of the lamp, we may follow the course of the current through the mechanism. First of all, it may be stated that there is a worm on the motor-shaft, gearing to the rod which carries the upper carbon. When the motor turns one way, therefore, the carbon is lowered, and it is raised if the motor is reversed; this action is, moreover, of considerable force, requiring a strong effort to stop it by the hand, and such minor obstructions as a little dirt, rust, or roughness, often so troublesome in lamps actuated by gravity, are of very little consequence when there is the force of the dynamo itself behind the motor.

The coils, it has been suggested, may be divided into "brains" and "muscles." The coil I is a shunt across the arc, and acts as the brains or directive force, without itself doing the work. The field-magnets and armature of the electromotor are the muscles which, under direction of the brains, move the carbons. On entering the lamp the current first traverses the series coils of the electric motor, then going to the upper carbon and across the arc to the lower carbon, and so back to the main wire. At the carbons, however, a shunt wire leads to the contact, Q, and to the shunt coil, I. The little motor is wound so that its armature is a shunt to the field-magnet, but is so arranged that it is a shunt to either the coil H or the coil H^1 according to the contact made by the vibrating arm, M.

The shunt wire is shown in the diagram by dotted lines. The wire of this shunt circuit is bared at the crossing between the coils, and is connected at this point to the brush, G, of the armature of the little motor; the other brush being connected to the vibrating contact, M, which, under action of the coil, can connect either with N upwards or O downwards. O^1 is an insulating stud. The pull of the coil I upon J is regulated by a screw, L, acting upon the core of this coil.

It will be easily seen that when the coil I acts upon the piece of iron, J, the shunt current is sent through the armature of the motor in one direction, while if it releases it, letting M touch at N, the current will be in the reverse direction. In any electric motor, to reverse the current in the armature, while the current in the field remains the same, is to reverse the rotation of the motor, and this action of the coil I upon the vibrating contact M keeps the motor almost constantly in motion one

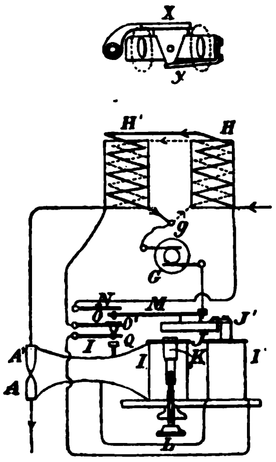

Fig. 3.

way or the other. When the arc becomes long, its resistance increases and more current goes through the shunt-coil, I; this moves lever M, sending a slight current through the motor armature, which feeds the carbons downwards by almost imperceptible motions. Should the arc from any cause increase to too great an extent, the shunt-coil pulls strongly on the lever, M, causing it to press together, by means of the insulating stud, O^1, the contact points P, Q; this short-circuits the arc through the other coil I^1, thereby increasing the pull on the lever, and ensuring good contact between P and Q.

The lamp may be made to strike any desired length of arc and feed at any potential by altering the position of the contacts N and O. The potential on the armature of the motor is two volts.

The arrangement for starting the lamp and striking the arc are shown in plan at the top of the diagram, and can also be seen at the base of the lamp in the other illustration. The lower extremity of the armature-shaft is pivotted at its lower end in a movable V-shaped yoke, X. This, when the lamp is working, is attracted by the field-magnets completing their magnetic circuit, and at the same time throwing the worm into gear with the wheel, which raises the carbons and strikes the arc. When the lamp is not working, the movable yoke is pushed back by a spring, Y; the worm being thus released from the wheel, the rack falls, and the carbons come together.

The burning of these lamps is extremely regular; it is hardly too much to say that not the slightest flicker is ever noticeable to the eye.

Lamps of this description have been burning for some time past in Kensington High-street, near the Albert Hall,

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run two in series on the 100 volt incandescent circuit, and have given every satisfaction; and it is understood that there are some hundreds of them in the Paris Exhibition.

These lamps, which are also made focussing or double carbon, are constructed by the Planet Electrical Engineering Company, Limited, Victoria Mansions, 28, Victoria-street, Westminster.

PECULIARITIES OBSERVED IN TESTING MATERIALS.*

BY W. CLELAND, B.SC.

(Concluded from page 312.)

Before considering the curves for stress and strain I may mention some experiments of Bauschinger "On the Alteration of the Elastic Limit in Iron and Steel." The extract is taken from *Engineering*, Nov. 25th, 1887:

"An interesting series of experiments on the alteration of the elastic limit of iron and steel, which have now extended over several years, have been made by Prof. Bauschinger, at the laboratory of the Technical School, Munich, and some interesting and important results have been obtained. Most of the experiments were made on one of Werder's testing machines, the deformations being read by Prof. Bauschinger's mirror apparatus, but for the experiments on the endurance of bars a Wohler machine. In the course of these experiments it was discovered that the breaking down point (yield point), had no connection with the elastic limit; thus, when a series of gradually

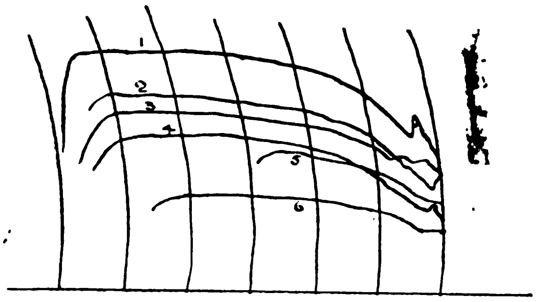


Fig. 10.—Curves showing Variation at Breaking-down Point (Kennedy). 1. Swedish Iron. 2. Shelton Bar Iron. 3. Swedish Iron. 4. Landore Rivet Steel. 5. Cast Steel. 6. Landore Plate.

increasing stresses exceeding that corresponding to the original breaking down point (yield point) of the material were applied to the bar, this point rose with the stress and this rise was continued for weeks and months, and possibly years, if the bar was left at rest under the greatest of these loads On the other hand, when a bar was subjected to an increasing stress greater than that corresponding to the elastic limit of the material, but less than the stress at the breaking down point (yield point), the elastic limit and elastic modulus both increased, but reached a maximum as the breaking down point (yield point), was approached, and then rapidly decreased, the former at times even reaching the value zero. If, however, the bar is left at rest under a stress exceeding that of the primitive breaking down point, the elastic limit and elastic modulus increase again, and the former may attain a point far above its original value. Moreover, the elastic limit in tension is in general very different from that of the material when subjected to compression, and artificially raising the elastic limit in tension as described above caused the elastic limit in compression to be decreased, and this may even pass through the point of zero stress. In other words, a bar of steel or iron has two elastic limits, and whatever position these occupy on the scale of loads, the range between them is nearly a constant quantity. By alternately stressing a bar in tension and compression just beyond the elastic limits, these, after a certain number of repetitions, occupied positions equally distinct from the point of zero load, and the limits thus obtained are called by Bauschinger the natural elastic limits of the bar. It was then noted that the stress corresponding to these limits sensibly coincided with that found by Wohler as the limiting stress to which a bar could be subjected to alternate tension and compression. It would thus appear that a bar will bear an indefinite number of repetitions of stress, provided the range of stress does not exceed the elastic range mentioned above."

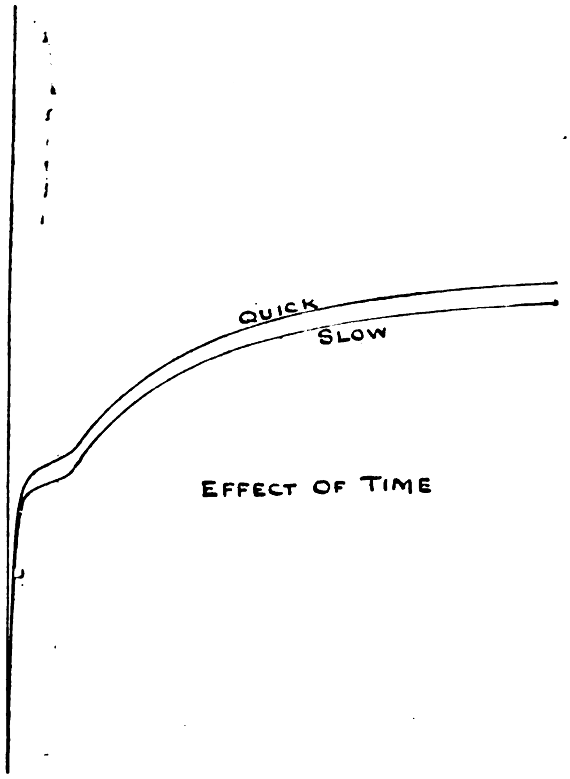
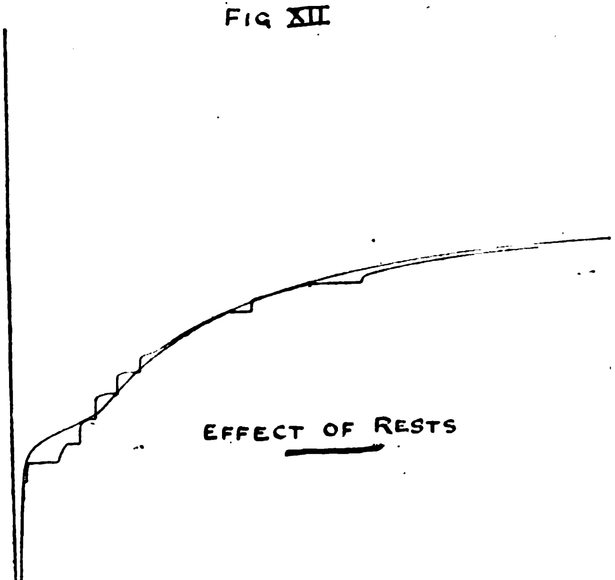


Fig. 11.

We have so far discussed the external features presented by metals when under test; but we gather far more information from a study of the curves connecting stress and strain. The life history of the specimen is written there so plainly that those who run may read. In Fig. 4 I have drawn an exaggerated form of the curve, in order that the

Fig XII



characteristic features may be seen more distinctly. A, B, C, D, E, F represents the curve as got from iron or steel, as regards the distinguishing points. For copper or brass, the part B, C, D of the curve is absent, and even with steel in certain conditions. From A to B the curve is a straight line showing the proportionality of stress and strain, or Hooke's law. B is called the elastic limit, and

* Paper read before the Physical Society, Glasgow.

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beyond this point the stretching increases till we reach C, when the material yields to the stress or breaks down. This point, C, is called the breaking down point, or yield point. The stress now becomes smaller, while the strain increases until we reach D, where the specimen seems to recover itself, the stress now increasing along with the strain. At E we have attained the maximum stress, and local contraction sets in. At this point we have an action similar to what takes place at C—that is, the strain increasing while the stress is diminishing until F is reached, when the specimen breaks. I have given along with this paper some curves for iron, brass, copper, and indiarubber, drawn by Prof. Barr's wire testing machine. Some of the points mentioned above are not seen in the curves. For example, the part of the curve for iron beyond the breaking point does not show any hollow, and in neither the iron, brass, or copper is there any trace of local contraction. This is a defect in the apparatus. There is no arrangement made to allow of the reduction of stress. We have made experiments to try to remedy this, but up to the present these have been unsuccessful. The

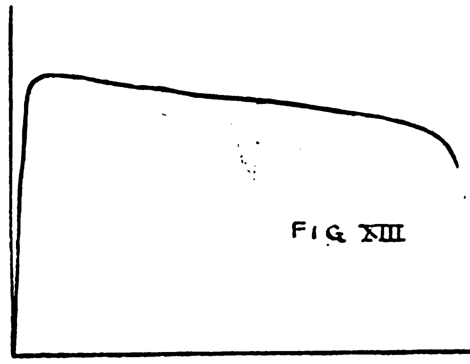

FIG. XIII

Zinc Curves.

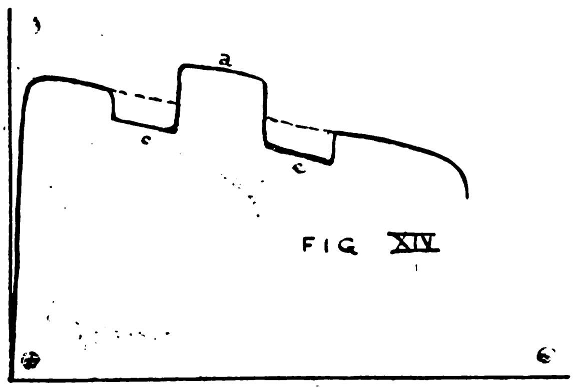

FIG. XIV

elastic limit in the case of copper and brass is well marked in the curves, but no such point can be observed in the curve for indiarubber. It has rather a peculiar history: altogether apart from that of metals. The stress and strain at first increase almost uniformly up to a certain load; after this the strain is very much greater than the stress. But towards the end of the curve the state of matters is reversed; the strain now becomes almost nil, while the stress increases very rapidly. This is experienced when we attempt to stretch an indiarubber band. At a certain point the indiarubber becomes almost as rigid as metal. I think, however, that the most peculiar point about these curves is the form of the curve at the yield point. It seems due to some artificially created restraint of the particles, which at this point suddenly breaks down; but if this were the case, annealing should have the effect of abolishing this point. Fig. 9, taken from Prof. Unwin's book on "Testing of Materials of Construction," shows the effect of annealing and hardening manganese steel bars. It rather leads one to the belief that the particles of a body are brought to their natural state through hardening. This disappearance of the yield point is not a characteristic of manganese steel bars only; it has been noticed in some hard steel used for rails. I have copied some diagrams of Prof. Kennedy's to show how the yield point varies with different materials. It has been stated that since at this point extension takes place very rapidly, the peculiarity may be due to inertia; but, in the autographic apparatus used for the above curves, the effect of the inertia of the load is eliminated. Time is another reason which has been given. In the curves given in Fig. 11 showing the connection between testing two specimens of wire from the same coil, we see the difference at the breaking down point. It is assumed that if the rate of test were slow enough, the bend in the curve at the breaking down point would get smaller and smaller, so that the result would be after this form. The curves are drawn after the shape of those got from Prof. Barr's machine. The thick line indicates the assumed last form of the curve with the test very slow.

In a previous part of this paper I have spoken of the effect of raising the elastic limit by stress. In Fig. 12 we have a diagram showing the point very clearly. When the curve has reached the point A, the load is taken off and the pen traces the line, A B. When started again, the pen goes back along the same line to A; but instead of taking up the curve of this point, it goes beyond it to point C. This point constitutes a second breaking down point. Beyond C a line, almost horizontal, is drawn until what would have been the continuation of the old curve is reached. It is seen that the same effect takes place at any other point on the curve. These points constitute new elastic limits, and are all greater than the primitive elastic limit. In Fig. 13 we have a similar result. The diagram is to show the effect of rests, and the result is strange indeed. Instead of describing a curve as one would have imagined, a line, almost vertical, is traced, when once the test is proceeded with again, and breaking down points experienced similar to those in the last figure.

I will close this paper with two diagrams given by Mr. Martens. They are both for sheet zinc, and the second one shows very clearly the result of changing the rate of test. He says, "with sheet zinc he had obtained diagrams with his diagram apparatus, which usually had the form shown in Fig. 13 when the work was done with uniform velocity. If, however, during the experiment the velocity of extension was changed, the diagram had somewhat the appearance given in Fig. 14; with a low velocity the distance, *c* and *e*, with high velocity, *d*, was traversed. It was easy to obtain differences in the force ordinates, which amounted to more than one-third of the maximum heights. In a similar way, he was able to prove that with steel a diminution of resistance of about 1·3 per cent. was effected by slow operation, under by no means exaggerated conditions."

LITERATURE.

The Telephone. By W. H. PREECE, F.R.S., and JULIUS MAIER, Ph.D. London: Whittaker and Co., 1889.

"'Tis as great a fault to judge ill as to write ill, and a more dangerous one to the publick." So said a writer whose name is celebrated in English literature, whose works are to be found in every respectable library, but whose genius is unappreciated by the present generation. Another great writer, still living among us, speaking of the historian Buckle, says, "Every man, so Buckle said, acted from a motive, and his conduct was determined by the motive which affected him most powerfully. Every man naturally desires what he supposes to be good for him; but to do well he must know well." If Buckle's contention be true, then every man who writes a book does so from an all-powerful motive. It is not necessary that the motive should always be a pecuniary one, and we are fain to hope that while this may play its part the writers of technical books have something higher and nobler as the mainspring of their labours. Be that as it may, "to do well" requires "to know well." A man full of his subject pours it forth without appreciable effort, while the man who knows less trips very haltingly. There is a class of book very important in its way, however, which hardly falls within the category of those that require to know in order to do. And to this class we consider the book before us belongs. In thus judging we have in mind the dictum given in the first sentence above. Our conclusion is based upon the fact that the work seems rather that of a compiler and abridger than of an author. It gathers together the fragmentary history of the

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development of telephony as found scattered through various ephemeral publications of the past ten years. Here, then, we have given in a consecutive, compendious form the history of and existing practice in telephony, linked together by short essays of a more theoretic character. Such a book would neither make nor mar an author's literary reputation, but it would indicate, when well done, a careful, painstaking investigator. According to our views and classification, this book is well done, and shows that the authors have made a most extensive, even if it be not absolutely exhaustive, examination of the current literature on the subject. We find brief references to early writers on transmission of sounds and speech to a distance, till the work of Bell, Edison, and Hughes gave the telephone a practical form. The theory of the subject is dealt with in a short and simple manner, and the bulk of the book consists in the description of apparatus and systems employed in various parts of the world, together with statistics on the subject. All this is extremely interesting, but hardly calls for criticism. There can be no differences of opinion as to the value of a clear description of Brooks, the Pattersen, the Post Office, the Felten and Guilleaume, or any other underground cable. We are glad to see and must congratulate the authors on their cosmopolitism. Telephony does not owe much to England, nor can our factories vie with those of the Western Manufacturing Company in the production of apparatus. No doubt we copy the types of apparatus produced by other manufacturers, and after giving them a distinctive colour, appropriate them as our own design. Such a book as this will assist in determining the progenitor of instrument or system. There is one feature against which we must protest. If publishers will use borrowed blocks for illustrations, for goodness sake anglicise French blocks in English books. Take as an example, Fig. 172, p. 364. In the text we rightly get "central office," in the figure *bureau central*. In the figure you get *signe d'abonné*, *poste d'abonné*. You get reference letters not mentioned in the text, and so on. This is annoying, to say the least, and ought not to be tolerated in a book of any pretensions. We have almost said our say. The book should be in the hands of every man and woman whose livelihood depends upon telephonic work, for none ought to be so engaged without desiring an appreciative knowledge of the subject such as they may here obtain to perfection.

OBITUARY NOTICES.

WARREN DE LA RUE.

We regret to announce the death of Mr. Warren de la Rue, D.C.L., F.R.S., Ph.D., which occurred on Good Friday. He was the son of the late Mr. Thomas de la Rue, and was born in Guernsey in the year 1815. He was educated at the college of St. Barbe, Paris, and succeeded his father as head of the firm of Thomas de la Rue and Co., from which he retired in 1880. In the course of his conduct of the firm, Mr. de la Rue applied his scientific knowledge to purposes of practical utility, and patented a number of inventions, among them being processes for utilising earth oils, and machinery for simplifying the making of writing materials. The principal scientific work in which he distinguished himself was the application of photography to the recording of celestial phenomena. The photographs, when measured by a micrometer which he invented, furnished exact astronomical data. In 1860 he went to Spain with the Himalaya Expedition, and was successful in obtaining a series of photographs of the total eclipse of the sun on July 18. The results formed the subject of the Bakerian lecture delivered to the Royal Society in April, 1862. In conjunction with Prof. Balfour Stewart and Mr. B. Lowry, he published "Researches in Solar Physics," founded on observations made at the Kew Observatory under his directions. He also took an active part in making the preparations for the photographic observation of the transit of Venus in 1874. He established a private observatory at Cranford, Middlesex, but it was dismantled in 1873, and the instruments presented to the University of Oxford, where they have been employed most successfully by Prof. Pritchard in determining, by means of photography, the distance of 61 Cygni and other fixed stars. In 1874 he fitted up a private physical laboratory, where, employing a battery of 15,000 chloride of silver cells, he has, in conjunction with his friend, Dr. Hugo Müller, carried on an elaborate series of researches on the electrical discharge. The results of the researches have been from time to time communicated to the Royal Society and the Académie des Sciences, Paris. "The Phenomena of the Electric Discharge" was also made the subject of a most interesting lecture, illustrated by a great number of experiments, at the Royal Institution in 1881. Nearly all the results of Dr. de la Rue's scientific work have been embodied in papers and memoirs, which will be found in the *Transactions* of the Royal Astronomical, Chemical, and other learned societies. He acted as juror and reporter in the Department of Class XXIX. in the Great Exhibition of 1851, was a juror in Class X. of the Paris Exhibition of 1855, and presided over Section B, Class XXVIII., of the Exhibition of 1862. He was a member of the International Electrical Congress, consisting of all the most eminent physicists of all countries assembled in Paris, and of the jury of the Electrical Exhibition held there in 1881. He was also a member of the Consulting Council of the Electrical Exhibition held at the Crystal Palace, Sydenham, in 1882. He has held office in several societies. He acted for some time as honorary secretary of the Royal Astronomical Society, of which he was also president from 1864 to 1866. He was president of the Chemical Society from 1867 to 1869, and again in 1879-88, and was till his death one of its vice-presidents. He was for many years president of the London Institution, from which he retired and became secretary of the Royal Institution, in 1878, on the retirement of Mr. Spottiswoode, who was elected president of the Royal Society, but resigned the post in 1882. He was a corresponding member of the French Académie des Sciences, for the department of astronomy; also of the Imperial Academy of Sciences, St. Petersburg, the Philomathic Society of Paris, the Royal Society of Upsala, the Society of Agriculture and Commerce, Caen, the Society of Natural Science, Cherbourg, and the Berlin Chemical Society. Three foreign orders have been conferred upon him: Commander of the Legion of Honour, Commander of the Order of St. Maurice and St. Lazare, and Knight of the Order of the Rose, Brazil. Mr. de la Rue died, after a short illness, from pneumonia. The funeral was at Kensal Green on Tuesday last.

ROBERT STERLING NEWALL.

It is with extreme regret that we chronicle the death of Mr. Robert Sterling Newall, F.R.S., of Gateshead-on-Tyne, whose name is well known in connection with the invention and manufacture of wire rope, and the early history of telegraphy. Born in Dundee, in 1812, of an old and respectable Scotch family, he entered a mercantile office, and afterwards came to London, where his talents found more genial employment, under the late Mr. Robert M'Calmont, in connection with experiments on the rapid production of steam. In 1840 Mr. Newall took out a patent for making wire rope. It was this invention that made submarine telegraphy possible. He established works at Gateshead, and his firm manufactured and laid the Dover and Calais cable in 1850, the Holyhead and Howth and Port Patrick in 1852, and the Dover and Ostend, the Frith of Forth, and the Holland cables in 1853. In November, 1854, Mr. Newall suggested a cable from Varna to Balaclava to the Duke of Newcastle, then Minister for War. When this cable was completed, Mr. Newall received the thanks of the Duke of Newcastle. The Black Sea cable was laid by Mr. Newall in 1855, and the Red Sea cable in 1859. After laying the latter, Mr. Newall was wrecked in the "Alma," when his courage and coolness proved of the greatest help to the shipwrecked passengers. He devoted much of his time to scientific work, and had constructed a 25in. refracting telescope, which just before his death he offered as a gift to the University of Cambridge. To local matters Mr. Newall devoted much of his time. He was twice Mayor of Gateshead, and he was unanimously asked to be mayor again this year, when the British Association visit Newcastle.

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THE

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

ANXIOUS FOR DETAILS.

Through the courtesy of the editor of *Industries*, we were acquainted last week with the information he had received from Messrs. Ganz, of Buda-Pesth, relating to that firm having obtained a practical alternate-current motor. It seemed to us, however, that it was only right the initiative of our contemporary should be respected, and, so far as we know, credit must be given to *Industries* for being first to bring this matter before the English public. We hope shortly to be able to give further details of the motor, with drawings, but the vista opened out for immediate development of the electrical industry in regard to transmission of power, if this motor be as economical and successful as is claimed for it, is almost brilliant enough to take one's breath away. The one thing needful, might be the phrase used in connection with an economical alternate-current motor, and if this is really to be had there is no possible means of estimating the business to be transacted in electrical matters in the immediate future.

We write in this strain, although we know that the advocates of alternate currents have not thoroughly grasped the problems before them in dealing with vast networks of underground wires. The writer claims to have been the first to point out the necessity for taking into consideration what is now termed self and mutual induction, and also certain questions connected with alternate current distribution which are now becoming prominent. The rising class of electricians is inclined to despise some of the old-fashioned work of Willoughby Smith, F. C. Webb, and others, in face of the brilliant suggestions and hypotheses introduced by the younger men. Mr. Sprague must at times laugh to himself to find how far the views advocated by him nearly a quarter of a century ago are, under other auspices, becoming fashionable. Sermonising, however, is not now our object, nor is it the setting up of the ancient in face of the modern, but only to say, Don't despise the work of our elders, nor reckon it all rubbish. "There is nothing new under the sun" is an expression attributed to the wisest of the Eastern sages, but moderns take this as merely hyperbolic, and unhesitatingly affirm the doctrine of progress. Iron, coal, and water existed in the time of Solomon, but the combination resulting in the steam-engine did not. The action of magnets upon magnets, and wires conveying currents upon similar wires and upon magnets, has been descanted upon in textbooks for many years, but the various combinations to bring these actions into different practical uses are not even now all known, and probably never will be all known till human knowledge has reached the perfect state—a consummation, however much it may be desired, not yet within the bounds of our comprehension. In matters electrical, with so many in-

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telligent minds directed upon the problems awaiting solution, any day may come

> "When the faithful pencil has designed
> Some bright idea of the master's mind,
> When a new world leaps out at his command,
> And ready Nature waits upon his hand."

Eleven years ago, Paul Jablochkoff, at the Paris Exhibition, paved the way for a new era—the electrical era. Three years later saw the Electrical Exhibition at Paris, and since then exhibitions have been held by the score, in all of which electrical apparatus took first place. It is to be hoped that Messrs. Ganz will see their way to exhibit this new motor at the Paris Exhibition to be opened on Sunday, May 5th. Be that as it may, the introduction of the motor, if it is all that is claimed for it, will stamp the year as fixing the time of a new departure. There have been rumours as to the success and the non-success of previous inventors in this direction—generally their non-success—but nothing very definite could be elicited as to the amount of failure or success. We have before said, and we maintain our contention, that unless an economical alternate-current motor is to hand, the multiplication of central alternate-current stations is a mistake. With such a motor many of our objections fall to the ground, for light must become, as it were, a bye product, and be produced in this way in a manner sufficiently cheap to defy competition from gas.

The figures and information given by our contemporary intimate that the motor requires one circuit only, that it is capable of starting under a load, and has as fairly high efficiency. The figures show a commercial efficiency of from 77 to 81 per cent. in trials which are stated to have been carried out under slightly adverse conditions. All electricians await fuller and complete information with great interest, and we sincerely trust their ardour may not be damped by subsequent figures, and that the machine is quite equal to what we are led to expect.

PROF. ELIHU THOMSON'S NEW METHOD OF REGULATING CURRENT OR POTENTIAL IN THE SECONDARIES OF TRANSFORMERS.

It is but a few years since the designing of electro-magnetic machinery, in the broad sense of the word, was more a matter of trial and error than of calculation; and although in the case of the dynamo good machines were developed from the process, it was not until the work of Hopkinson, Kapp, and others on the construction of these machines appeared that dynamo-building can be said to have been reduced to an accurate scientific basis.

The principal factor which characterises the new method of dynamo construction is the treatment of the magnetic circuit in the same manner as the electric, so that the "resistance" of the magnetic circuit has come to be quite as important a consideration as the electric.

Without entering further into the importance of taking this fact into account, we desire to draw attention to a beautiful application by Prof. Elihu Thomson of the theory of magnetic resistance to the regulation of alternating-current apparatus, so that either constant potential or constant current can be maintained in the secondaries of transformers, independent of the external resistance of the circuits. While primarily designed for the purpose of maintaining constant alternating currents such as would be required for arc lamps, the method is applicable to other purposes, as will be described later. The regulation is effected by the direct action of the lines of magnetic force themselves, in concentrating or focusing themselves across a narrow non-magnetic space, forming a partial break in what would otherwise be a perfectly closed magnetic circuit for the magnetism developed by the current of the coil in question.

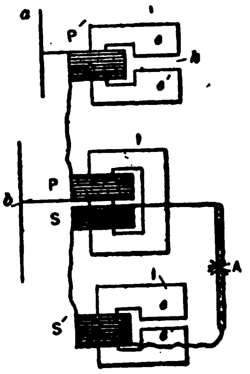

Fig. 1.

The method employed by Prof. Thomson will be best understood by referring to the diagram (Fig. 1). Here *a* and *b* are alternating current constant potential mains, the coil P being connected to them as a primary, S being the secondary, and both being wound on the same core. We will suppose that the number of turns in P or in any coil in circuit with it, as P′, is such that, having reference to the potential of *a b*, very little current will pass in P when the circuit of S is open. P′ is an additional coil wound on an iron core, I, in which core the alternating currents will obviously produce an alternating magnetism, and if the core of this coil were continued around so as to be endless, there would be a magnetic circuit entirely closed and a maximum of reactive effect in the coil P′ opposing the passage of current from *a* to *b*. Instead, however, of making the magnetic circuit completely closed, the core is provided with projections, *e e′*, which are brought rather closely together, with, however, a determinate air space between them, forming a partial break in the closure of the magnetic circuit for the magnetism developed by the current flowing from *a* to *b*. The space forms an air or magnetic resistance to the closure of the magnetic circuit for coils P′, and, as will be obvious, the more perfect the closure of the magnetic circuit at this variable point the greater will be the reaction upon the currents flowing from *a* to *b* through coils P′. During normal flow of currents from *a* to *b* there is a definite degree of closure of the magnetic circuit at *k*, dependent upon the width of the space and the number of magnetic lines of force which, with the given strength of magnetism in the core of P, may force themselves across the space. If there is any tendency to increase in the magnetism of the core of P′, the lines of force concentrate or mass themselves together in the space across *k* and become less diffused. By this means the degree of closure of the magnetic circuit of the core is increased and the reaction in coils P′ increased. This variation of partial magnetic closure or variation of magnetic resistance obviously takes place independently of the magnetic circuit formed by the core threading the coils S.

Leaving out of consideration the coil S′ in the circuit of S, the operation in regulating or adjusting the current in the circuit of secondary S is as follows: When there is a tendency to increase of current in the circuit of S, due to decrease of resistance, there is an attendant decrease in the counter E.M.F. of the primary coil P, as is well understood, and there would hence be a tendency to increase of flow in the coil P; but with an increase of flow in the coils of P there is also an increase in the coils of P′, and an increase in the number of lines of magnetism which pass over the magnetic resistance at *k* is produced. Inasmuch as the reaction of the coil P′ depends upon the

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amount of magnetic disturbance set up in its core, or the number of lines passing from *e* to *e′*, it is obvious that the currents flowing from *a* to *b* will meet an increased self-inductive reaction, and the current on the secondary circuit S will be cut down.

As the rate of variation of closure at *k* may be varied by any desired means, and may, in fact, be determined by the width of the space *k*, it is obvious that the regulation or the adjustment of current in the circuit of S may be of any desired nature. The prime object is, however, to secure a practically constant current in the secondary circuit, and the width of the gap *k* is made such as to produce as near as may be that effect. The regulation of the current or potential in the secondary circuit might also be produced by variably closing a magnetic circuit developed by the secondary current and independently of the magnetic circuit of the primary current. Thus, as indicated at S′, the secondary current may pass through a coil which shall set up magnetic effects in a core having a partial magnetic closure of variable amount, as at *k*. In this case the same effect of a reduction in the current or potential of the secondary is produced by the variation in

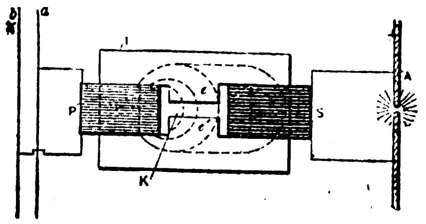

Fig. 2.

inductive reaction at the coil S′, secured by variably closing the magnetic circuit of the core of S′ at *k*. The effects produced by the variation of magnetic closure of the core excited by the secondary current might obviously be used alone or in conjunction with similar effects produced in the primary, as at P.

Instead of varying the magnetic closure of a core surrounded by a separate coil, as shown in Fig. 1, the magnetic circuit for the portions of core of the coils, P S, themselves may be variably closed, each portion of core having its magnetism closed without passing through the other portion, as shown in the coil (Figs. 2 and 3), which is the actual construction adopted. This is accomplished by means of

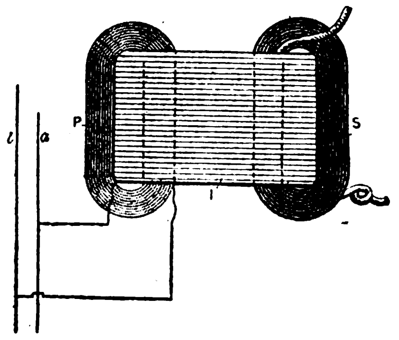

Fig. 3.

projections, *e e′*, extending from some part of the iron core or circuit which threads both the primary and secondary coils, the projections being separated from one another by a space K, forming a magnetic resistance similar to the space *k* of Fig. 1. By means of the variable magnetic resistance formed at K, the magnetism developed in the portion of core surrounded by the coil P is variably closed. In fact, the magnetism can work, as it were, through two magnetic circuits, one including the space or resistance K and the other including the portion of core passing through the coil S. The magnetic lines developed by the core or coil P, which pass through the air space at K and escape the coil S, produce wholly self-inductive effects, resulting in an opposition to the flow of the primary currents, while all the lines developed by the coil P which pass through the axis of the coil S result, as usual, in the production of secondary currents.

It will be readily seen that, as before described, any tendency to increase of the current flowing in coil P, resulting from a lowering of the resistance in the circuit of S, will be at once followed by the development of increased magnetisation of the proportion of core in coil P by the formation of increased magnetic lines across the air space, while at the same time the self-induction of the coil S itself will undergo an increase, owing to the fact that a path of variable closure for the magnetism in the core is likewise formed across the space K. In fact, the effect of a slight increase of current in the coil S would be to oppose the passage of the lines of force tending to pass through its coils from the coil P and cause them to be shunted across the space K. The result of all this is that the varying resistance in the circuit of the secondary, S, would receive a current which tends to be limited in strength and to be self-regulated through the provision of the variable magnetic resistance formed at the point K′ on partial closure of the magnetic circuit for the cores of the coils. As will be observed, the effects and principle of operation are much the same as before explained in connection with Fig. 1, excepting that the partially-closed path here permits the added effect due to the beating back of the inducing magnetism in S, and, in effect, results in a shunting from S of the magnetism developed by coil P.

In Fig. 2, A represents an arc lamp, fed with constant current from the secondary, P, although the primary coil, S, is subject to constant potentials. If the distance between

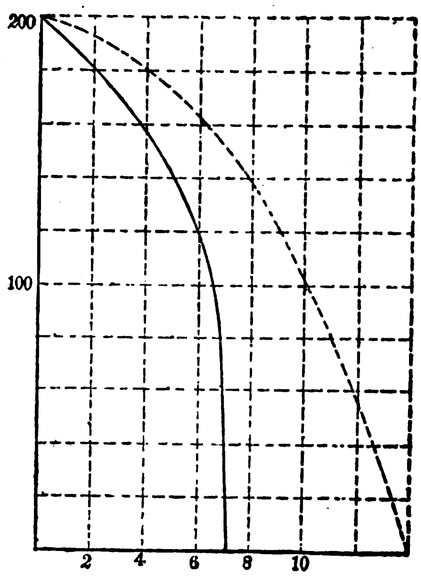

Fig. .

the projections, *e*, be properly determined, it will have the peculiar property of producing in the secondary coil, S, a droop or fall of E.M.F. when the resistance is cut out of the circuit, and this fall may be made nearly proportionate to the fall of the resistance, or diminishing resistance in the circuit, thus maintaining the current constant.

The partial closure of the magnetic circuit of the core, I, may be produced outside of both coils, P S, instead of between them. Other methods may also be employed, and a variety will readily suggest themselves.

The full line, Fig. 4, illustrates what may be called the "characteristic curve" of the secondary currents in such a coil as Fig. 2, the verticals or ordinates representing the E.M.F.'s evolved, and the horizontals or abscissas the current strengths corresponding thereto. At E.M.F.'s below 100, as shown, the curve is almost a vertical line, showing that a constant current is evolved at any resistance below that corresponding to a potential of 100. The dotted curve represents the case of drooping or falling potential with increase of current, such as is obtained with some special arrangements, such as that shown in Fig 1.

While, as stated above, the method is applicable primarily to the operation of arc lamps on constant potential alternating circuits, it has a variety of other uses. Thus, it may be employed to maintain constant current in a number of incandescent lamps placed in series, any one or all of which may be switched out of circuit without danger. Another application is the maintenance of a wire at uniform heat independent of the length in circuit. Still

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another is the use of the method for maintaining a constant current in electric furnaces which, as is well known, are liable to sudden and great fluctuations in current, and thus are a constant menace to the dynamo feeding them. Other applications will readily suggest themselves, but enough have been mentioned to indicate the wide scope of Prof. Thomson's method of alternate current regulation.—*Electrical World.*

BERRY'S DOME ELECTRIC BELL.

The requirements of an electric bell are that it should be neat, simple, cheap, well made, and that it should ring with the minimum of battery power. Mr. F. H. Berry, of 18, Percival-street, Goswell-road, has brought out a self-contained dome electric bell, which has been designed to satisfy these requirements. The bell is shown in Fig. 1, mounted on a mahogany case, with silver-plated dome or bell. The working parts of the bell are hidden beneath the dome, and cannot be tampered with unless by unscrewing with a screwdriver.

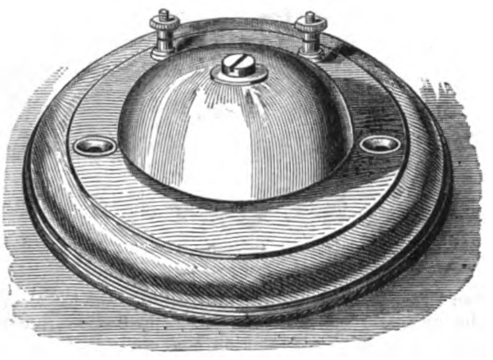


Fig. 1.

Fig. 2 shows the working parts of the bell, the dotted line showing the position of the dome. There is one magnet-coil only, but the power of both ends of the magnet are utilised by the provision of iron checks on the magnet, which attract the small armature or hammer placed alongside. This strikes the bell upon a knob or projection cast upon its inner surface. As there is only one bobbin, instead of two, this bell offers considerably less resistance

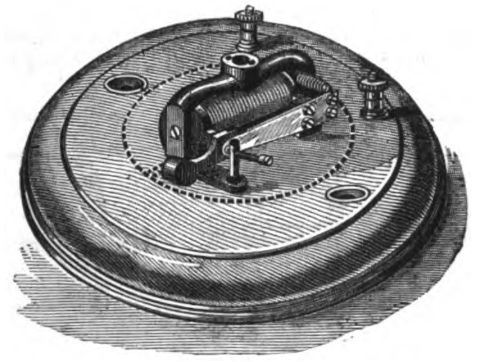


Fig. 2.

than the usual type, and works with less battery power. It rings very powerfully over 100 yards or so with a single Leclanche cell. The bell is very cheap, cheapness in this case being obtained, not by inferior materials and workmanship, but by the simplicity of construction, and considering the demand there exists for a really good and cheap electric bell, we should anticipate a very large sale for it.

Electrolysis by Alternating Currents.—The priority of observations on this subject is claimed by E. Drechsel in *Beiblätter* (1889, p. 13). He notes that the explosion of the gases is not caused by heating of the electrodes, as the same phenomenon occurs when the electrodes were of fusible metal, which afterwards show no trace of fusion.

UNDERGROUND CONDUITS AND ELECTRICAL CONDUCTORS.

BY JOHN B. VERITY (MEMBER).

(*Continued from page 320.*)

The Lake conduit shown in the illustration (Fig. 1) is made from the best stoneware clay, vitrified and well glazed. This conduit, said to be used with success by the United States Electric Lighting Company at Washington, is constructed with six compartments, each being 2½in. by 4½in. It is delivered in short lengths, and the joints are protected by stoneware covers set in cement.

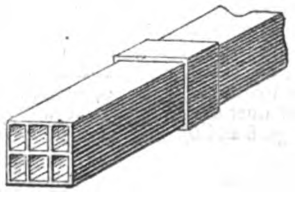


Fig. 1.

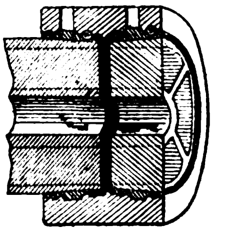


Fig. 3.

The Doulton conduit (Fig. 2) consists of a glazed earthenware pipe, in which the cables are laid, separated by toothed insulating partitions. A space at the bottom drains off the condensed moisture, which is got rid of by suitable traps. The joints are made like ordinary drainpipes.

A serious objection to such conduits seem to be the joints, which are made with cement. It is very difficult to break a cement joint without also breaking the pipe, and as it might be necessary at times to put in a new length, this could not well be done. Again, the rigidity of a cement joint is a disadvantage, as in laying earthenware pipes it becomes necessary at times to alter the alignment.

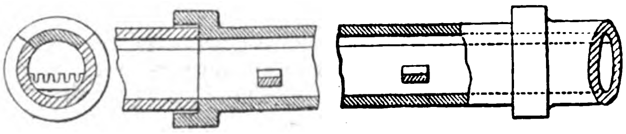
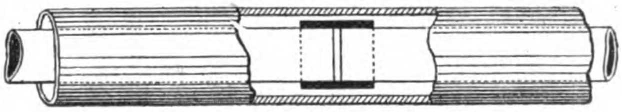


Fig. 2. The Doulton Conduit.

The Hurlbut conduit system (Fig. 3) was designed to overcome this difficulty by means of a flexible joint. The joint is shown in the diagram. C represents asbestos gaskets recessed into the coupling and resting against the pipe. B is a cavity formed between the asbestos gaskets, and is filled with a permanently plastic sealing material. A represents openings through which the sealing material is poured. It is claimed that such joints will always remain both flexible and hermetically sealed.



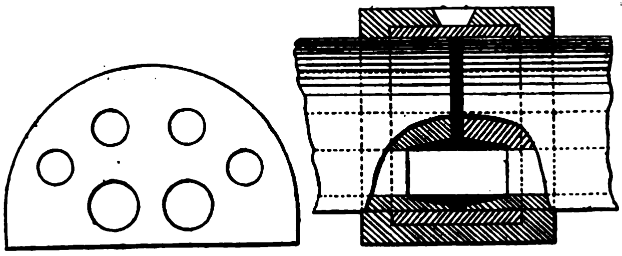


Fig. 4. Mr. B. Verity's Conduit.

Mr. J. B. Verity's conduit (Fig. 4) is a system of glazed stoneware clay conduit, with separate channel for each conductor; the joints are made as shown on diagram. The double cone-piece being inserted before the jointing material is run in, the special object of this conduit is to enable bare conductors to be used insulated only at the manholes or where they are likely to be handled. Experiments have proved this form to be capable of standing almost anything mechanically when laid on a fairly good bottom. Mr. Verity has also patented a system of glass tubes in iron pipes for the same purpose.

Pipes of glazed earthenware with several ducts form a good mechanical protection, being capable of resisting considerable crushing pressure, while the glazing both inside and outside provides also, under certain conditions, a first-class electrical protection. If it be desirable that the conduit should be formed of a non-conductor, then nothing could be better than such glazed earthenware, which also is of no great cost. The difficulty of maintaining good joints with earthenware pipes has been referred to some time ago in connection with conduits for telegraph purposes, several instances having been given by Mr. Preece and others of roots of trees, branches, and other vegetation having made their way through the joints.

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Is this capable of being overcome by a flexible joint, which should at any rate, prevent joints giving through expansion and contraction?

The great disadvantage, however, to the use of earthenware pipes in many places in a city like London is the amount of space required for them; in fact, the difficulty of laying any conduit at all in some of our streets will be found simply enormous.

As a mechanical protection only, it is immaterial whether the conduit be a non-conductor or not. The simplest form of such a duct is, of course, an iron pipe, and the Western Union Telegraph Company, among others, have laid cast-iron pipes of 4in. and 5in. diameter, with manholes, at a distance of about 450ft. apart. In the majority of cases, however, the plan has been to lay a number of separate iron pipes in a concrete bed, by which arrangement the pipes can be crowded, or curved, or kept apart, as may best overcome any difficulties or obstacles met with underground. For instance, four pipes may be laid on the same level in two layers, or where only a narrow excavation can be made, the pipes can be curved round so that two pipes are abreast in four layers. In this way the trenching is often materially diminished. Screw-jointed, asphalted, wrought-iron pipes of two or three inches diameter, laid in hydraulic cement concrete, are said to present the greatest tightness of duct against gas and water, together with the greatest strength (Figs. 5 and 6).

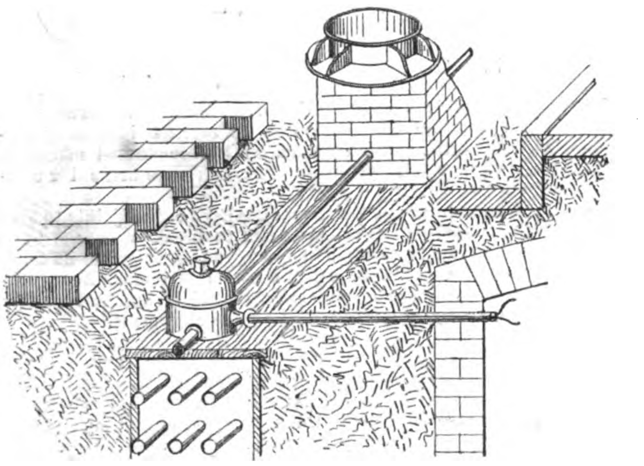

FIG. 5.

Cement lined sheet-iron pipes, however, possess some advantages, such, for instance, as smooth interiors, and the advantage of an iron enclosure, without the cable being brought into contact with it, and on the sheet-iron being eaten away, the cement still retains the pipe form. Zinc tubes again have been used, but are liable to be dented in, and asphalted concrete is often preferred to hydraulic cement concrete

Whatever system of pipes be used, it is important that they should have smooth interiors and close joints, and every conduit of whatever kind must be thoroughly well bedded, so as not to be liable to displacement from above.

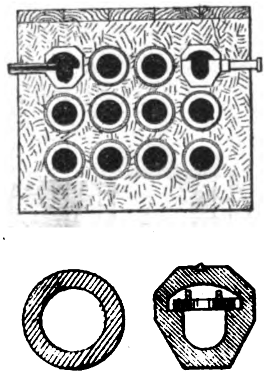

FIG. 6.

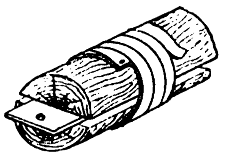

FIG. 7.

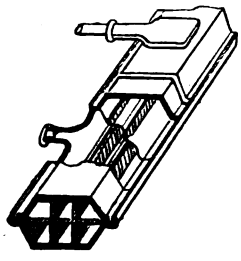

FIG. 8.

An ingenious conduit core (Fig. 7) has been devised by Mr. Chenoweth; a wooden cylindrical rod, 14 or 20ft. in length, is cut in two, forming two half-cylinders, and the space removed is occupied by an iron rod having a thickness equal to the portion sawed out. This forms the mandrill or core shown in the illustration; a ribbon of galvanised iron 1in. wide and a thickness of No. 27 gauge is wound spirally round this from end to end, securing the ends to the wood to prevent unwinding.

After painting the outside of the core with a mixture of clay, soapstone, and water, the core is placed in the ditch on crossed pieces of wood. If more than one duct is to be constructed, other cores are placed side by side, concrete is then well tamped round, bringing the top to an even level. The iron rod is then removed, as well as the two pieces of wood and the fastenings of the ribbon ends. When the cement hardens, the iron spiral can be drawn out at any manhole or unfinished portion of the work. It is claimed that the surface coating of clay and soapstone adheres to the interior of the duct and produces a smooth surface, while a monolithic structure is ensured water-tight by reason of its construction. I think this is another instance of American ingenuity.

The Johnstone iron conduit shown in the illustration (Fig. 8) is said to be very successful, and I saw portions of it as designed to be laid in New York City. It is made in sections about 6ft. long, and has six ducts; the three lower ones and the central duct on the top could be used for mains, and the two outer top ducts for house-to-house and street lighting. Where any house circuit is required the top half of a single section is taken and a new half-section with a hole in it, to which an elbow can be bolted, is fixed in its place.

A form of conduit made by Mr. W. E. Irish, of Cleveland (Fig. 9), is also worthy of notice. In the illustration the conduit consists of a tubular pipe cast in sections with flanges which are recessed on the inside to receive a rubber ring, forming a gasket between the two sections when bolted together. The conduit is provided with a longitudinal slot or opening along the top with inwardly-inclined sides, and flat surfaces on either side of the slot, to which the cover is secured by screws. To prevent the entrance of moisture through this slot, a strip of rubber or leather is first laid on the top of the flanges extended from one outer edge to the other. On this a solid wedge-shaped piece, which fits into the slot snugly, is placed, so that on the cover being screwed down the wedge, with the packing surrounding it, is forced into the slot, so as to seal it perfectly. It is claimed that there is great convenience in laying wires with this conduit, and that

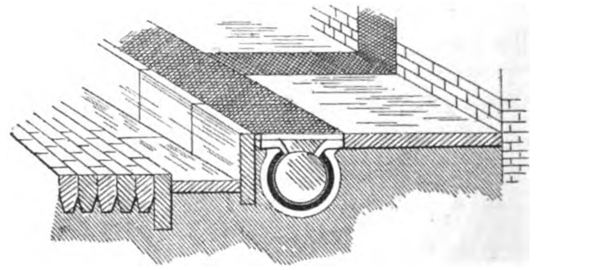

FIG. 9.

any wire can be tapped at any point by simply removing the cover and making the necessary connections. The illustration represents the conduit with a branch, also a junction-box, etc.

Fig. 10 represents Mr. J. E. H. Gordon's system as used by the Metropolitan Electric Supply Company. The cables are drawn into an iron pipe, and smaller iron pipes are led from the house junction-boxes to carry the wires for house lighting. Testing-boxes of a larger size, and built of brick, are provided at intervals.

It is generally admitted that an important point in underground work is good manholes. Mr. W. D. Sargent, in a paper read before the National Telephone Association, 1888, said that within reasonable limits it is almost impossible to get these manholes or working chambers too large, and that they have been compelled in many instances to rebuild and enlarge the manholes at first designed.

There is no doubt they must be of good size for convenience of drawing in and out, which is often a difficult matter, especially with lead-covered cables. In one instance, in Chicago, the manholes are built in octagon shape, in brick and cement, about 4ft. by 4ft., being made airtight with screw head and rubber gasket, and testing-boxes placed in them, so that troubles can be readily located, faulty wires drawn

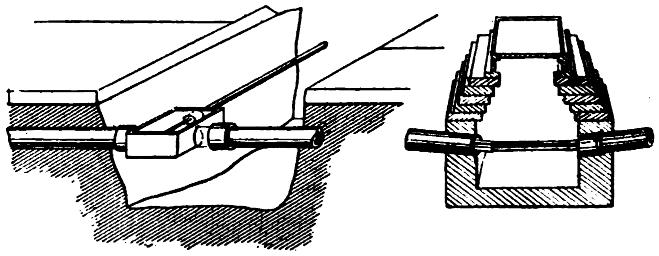

FIG. 10. Gordon's Conduit.

out, and good ones put in. In other cases the manholes vary from 3ft. 6in. to 5ft. deep, with iron kerbs and tops, and cement bottoms, and the covers made practically tight against water, many of the lids draining the water from the edge and collecting it in the centre, thus diminishing the liability to leakage at the gasket. With the Johnstone and the Irish conduits it is not necessary to provide for house connections, as the alteration can be made at any time afterwards when an application for light is received. But, as a rule, hand-distributing boxes made of cast iron, with screw head and rubber gasket, are fixed, one between every two houses, and after jointing the boxes are often filled with bituminous or insulating compound.

In the cement-lined pipe-conduit system one pipe is occasionally placed at the top for the house distribution, and connections made with the mains at the manholes. As to the frequency of these latter, much depends on the alignment of the conduit; at angles or changes of grade small manholes are necessary.

The combination kerb and gutter conduit (Fig. 11) shown in the illustration is worth notice. The kerb and gutter is made of fine concrete, one part of Portland cement, ten parts clean sharp sand, and

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three parts of broken stone, and the exposed surfaces coated with a granilitic mixture $1\frac{1}{4}$in. thick such as is now used for some of our London pavements. A conduit for electrical conductors of any reasonable size can be formed as shown in the inner angle of the kerb with hand-holes from above closed with iron covers at intervals at intervals. The illustration is taken from the admirable report on underground wires by Major Raymond, the engineer commissioner for the district of Columbia, and which contains valuable information on many points.

It has been suggested some time ago that the kerbstones should be removed from busy thoroughfares and replaced with a hollow kerb edged with cast steel, and the suggestion may bear fruit in the future.

As I still have to deal with electrical conductors I cannot here refer to the general cost of laying conduits as at one time I proposed doing. The principal cost, however, of laying them is in making good, and this depends on the material of the road, the cheapest being macadam (varying from 5s. per square yard) whereas asphalte would be nearer 20s. per square yard.

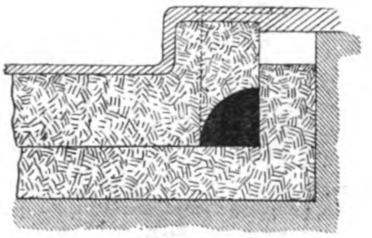

Fig. 11.

The difficulty of laying any form of conduit in some of our London streets must, as I have already said, be very great. The last comer will, of course, feel this the most; and although the Hydraulic Engineering Company may have recently had much trouble to find room for their pipes, the electric supply companies, again, will have an easier task than the Telephone Company, who are putting off the evil day.

As to what form of conduit is most suitable for London and our provincial cities there will be differences of opinion; but I trust the discussion following will narrow it down to a small issue, upon which such work can be undertaken with a tolerable surety of its lasting success.

There is really sufficient subject matter for a paper on conduits alone, and in taking up the question of underground conductors, I propose to chiefly restrict myself to a consideration of conductors for high-tension electric lighting circuits.

With regard, also, to underground conductors for low-tension work, I feel that the Edison system, as at present laid down, is thoroughly capable of filling all the requirements of house-to-house distribution. Many companies in the States and elsewhere are using it, and at the down-town station in New York it has been at work for the past six years successfully. In the recent discussion on Prof. Forbes' paper several points of interest concerning the Edison underground conductors were explained, which it would be unnecessary for me here to repeat. A full description of the latest developments of this system, with samples of the improved form of conductors, etc., are now on the ocean, and in the event of it being possible to provide another evening for a continued discussion of this paper, I shall be most happy to show and explain them.

Everyone must acknowledge the foresight shown in devising such a complete system of underground mains so long ago, and which, in spite of the all-round developments of electrical engineering, not only holds its own, but is still far ahead in completeness of any system for low-tension underground work. The Westinghouse Company have, I understand, acquired the rights for Great Britain, and presumably will use it in connection with large transformers for sub-centres. It may be also interesting to note that Messrs. Siemens have made concentric three-wire cables, which are being successfully used at Elberfeld, Geneva, and Mulhausen, and they state that the troubles from what would appear very complicated jointing have been satisfactorily overcome.

(To be continued).

BOARD OF TRADE ENQUIRY.

Wednesday, April 10.

Major Marindin, C.M.G., R.E., on behalf of the Board of Trade, resumed the enquiry at the Westminster Town Hall, for the purpose of hearing, on the part of a number of electric lighting corporations, their provisional orders to erect and maintain electric lines and works, and to supply electricity within certain areas in the metropolis and elsewhere, and the objections raised thereto by other companies and corporate bodies.

Sir Wm. Thomson wished to say, with reference to the answer he gave that one of the secondary supply wires ought to be connected in every case with the earth, that it was an opinion he arrived at after very careful consideration. Now that the pressure was proposed to be very much higher it would be dangerous to life, or, at all events, it would produce a very great shock if the metal-work of the lamps was at any such potential as 1,000 volts difference from the earth. There was no danger from fire. There would be an inconvenient shock if a person standing on a damp floor were touching a water-pipe or the lamp fittings. The larger the transformer, the larger the electrostatic capacity, and the greater would be the amount of the shock. His proposal was simply to connect one of the supply wires to the water-pipes; to let that be done through resistance of 10,000 or 5,000 ohms, and the result would be even in the case of a dead earth on the supply wire.

Mr. C. A. Cripps occupied a considerable part of the morning's proceedings by reading the draft agreement between the Metropolitan Electric Supply Company and the Strand District Board of Works, which had been drawn up by Mr. B. Maurice.

Mr. Moulton, Q.C., then opened his case for the Chelsea Electricity Supply Company, and in the course of his address said that it was the desire of all the representatives of the other companies who intended to give the continuous supply to do all that lay in their power to shorten the enquiry, and to assist the inspector by stating the points common to their various cases. That was to say, that in opening the case on behalf of the Chelsea Company he would as far as possible open the general case with regard to the direct supply system, especially with the use of storage batteries, simply so far as he was dealing with the scientific aspects of the question. He thought that their interests, so far as they came into conflict at all, came into conflict only on the question of area; but all the companies who proposed to use the direct supply had in common merits which were identical, and therefore, having stated the Chelsea Company's case, he would not have to repeat himself on behalf of the Electric Power Storage Company, and he would save the counsel who appeared for the Kensington and Knightsbridge Company and for the Westminster Company from the necessity of troubling the inspector with the same scientific details. He might also say that he appeared for the Telephone Company in order to put before him (the inspector) certain points that were now felt to be necessary to be mentioned, owing to the turn that some of the evidence had taken; but as he would have an opportunity of addressing him in opening the case before the enquiry was ended, he was not going in any way to deal with the evidence adduced on the part of the two companies whose cases had been already opened. The question of how far the evidence conflicted with the interests of his clients he would be able to show after all the evidence had been heard. The case of those for whom he was now speaking might be, he thought, fairly stated in this way. They were of opinion that the steps taken in 1883 and 1884, after very long and patient consideration of the subject, by the Board of Trade, were right substantially, and that there was no reason why they should be now departed from. He did not mean to say that knowledge and experience had not increased. He would be very sorry if that had been the case, but he thought that the bearing of electrical knowledge on the practical problem with which those electrical orders were intended to deal, had only justified and strengthened the grounds for the conclusions to which the Board of Trade then came. In 1882 the Electric Lighting Act was passed, in his opinion, under the influence of very strong feelings of what he might call a political kind. He did not mean to say that it was a party measure, but he did think that the Act was injured very seriously by the unmeaning importance which was given to certain political considerations as to the position of local authorities, and that it had one blot in it, which practically prevented electric lighting being carried out. He meant that the terms under which it could be done were given under pressure from the municipal authorities, and were such as could give no well-founded hope to undertakers of expecting a fair commercial return for their capital in the great majority of cases. That condition of things was altered by the Act of 1888. It was not one with which he could in all respects sympathise, but it did make some concessions to electric lighting companies in general, and admitted that the previous legislation was in error, owing to the unfavourable nature of the terms that it gave to electric lighting undertakings so far as the period of concession was concerned. That blunder, as admitted by the Legislature and corrected, did not affect in any way what the Board of Trade had to do in 1883. In that year the problem was this: Given a public need or a public desire for electric lighting, what was the fairest form of that special legislation which would limit and define the powers of the undertakers in each case? That was a problem which the legislation of 1882 had never attempted to deal with, and had most wisely left to the Board of Trade. The question of what the executive regulations should be was one with which the Legislature was thoroughly incompetent to deal with until the substantial problem had been worked out by such a body as the Board of Trade who had only the interest of the public at heart, and who, at the same time, could get the very best advice on the subject. What was the result during 1883, when there were many applications for provisional orders, a great number of which, he thought, but for that Act of 1882 would have been successfully carried out? Why, that the whole question on the receipt of those orders—or rather months before—had been most carefully thought out by members of the Board of Trade, and a model order drawn up, every line of which had been subjected to the closest examination and discussed, and the gentleman who had the shaping into legal form of that order was one for whose ability no one could help feeling the deepest respect. The case of the speaker's clients was that their provisional order was a right one, that it did even-handed justice between the local authorities and the companies; that it was not framed with anything like disregard to the claims of the local authority; and that the latter would do wisely to entrust to the company the lighting of their areas if they took upon them the responsibilities imposed upon them by that order. His company thought that as a company that went and asked for the powers of becoming undertakers for a district in London they ought to be willing to put themselves under such restrictions and responsibilities because under the period now allowed by the Legislature they would be able to do their duty with a fair and reasonable expectation of a proper commercial return. And he would say that where companies had at-

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tempted seriously to vary that order the Board of Trade should, in the interests of all parties concerned, decline to accede to their proposals, and that, practically, the model order settled in 1883 should be the order for the area they sought powers over. The Chelsea Company, that he represented for the moment, was, he thought, the only one that was bold enough to obtain, and try to carry out, an order under the terms of the 1882 Act, but it had a clause in the model order which was a most reasonable addition—namely, that supposing any general Act was passed later making the terms as to length of concession more favourable to electric lighting undertakings, they should have the benefit of it. With that very proper addition it took the model order, so far as he knew, *in extenso*, without any change of a material character. In 1886 they obtained those powers, but till the Act of 1888 was passed they were unable to set to work, because they could not get their capital. As soon as that Act was passed the capital was obtained and work commenced. Dealing with the special case of the Chelsea Company, let him consider what was the idea of those provisional orders. The particular form of provisional order in respect to area was a matter of exceptional consideration, even compared with the other cases of those orders, and the notion at the time was that a company should not have an area given to it unless it was prepared, in return for the privilege of the concession, to lay out a certain amount of capital within that area in actual works; and the reason was this, that they were going there for powers for an almost unknown industry—he would not say unknown in the sense of its never having been tried, but house-to-house lighting was a novelty—they were applying for an area over which they would have power to break up the streets, and it was said that in return for the order the inhabitants of the area, as well as the general public, had a right to demand from them that there should be a *bona fide* attempt to carry out the work, and that a sum of money proportionate to the circumstances of the case should be actually expended in works in the area in order that that attempt might be a real and not a sham one, merely for the purpose of keeping the area in their hands until they disposed of it for their financial good. One of the most important things to be gained by that was an increase of experience to the public, and it was most necessary that powers granted over an area should not be held simply for the purpose of disposing of them unless there was real work done. He could not help thinking that those compulsory works were an essential feature of the model order. On the other hand, it would have been very hard on companies to say, "We will define what you must do and all you can do." It would have been very hard on companies to do the pioneer work of putting down their mains at whatever cost to themselves if their system was bad and if the circumstances were unsuitable, and then say, "If you do that successfully you shall do no more, and other people shall be in exactly the same position as you are in with respect to powers for that which is the natural extension of what you are doing." So that the principle applied was this: "You must do something; you must state in your order what you will be willing to do as a condition of your getting the order. When you have done that, you shall be allowed to go into further portions of the area as soon as any need arises." The consequence was that all areas were divided into two parts. There was a part in which they had to do the compulsory work, and another in which extensions might be made when the need arose. That was the scheme which they said ought still to be carried out, and he thought that substantially that was the scheme which all the people who were going for the direct supply were perfectly willing to accept. The question seemed to be one of statutory duties and regulations, and he thought that it would be substantially found that the contest lay between two classes—those who wanted to adhere strictly to the policy of the Board of Trade in 1883, and those who wanted to throw it over, and that the discussion was practically conterminous with the alternating and the direct systems. For a small area the direct supply was the cheapest, best, and most convenient. It was best to the consumer, it was most easily capable of being regulated, and was the one which was farthest from the risk of extinction. If they were to roam over a big area—if they wanted to hold London by occupying and lighting the best pieces, not over a small, but a large area, so that they could keep out competitors by taking up the cream of the work, and not being obliged to do more than that—then let them by all means use the transformer system. It had, no doubt, an enormous advantage in dealing with a straggling supply. Distance from the generating source, distance between the different distributing stations, was now a matter of comparatively little moment. That which it gave to the consumer was far less valuable, while the dangers which attended it were far greater. Its liability to immediate extinction was incurable, but the distance between the centres of generation or distribution was quite a trifling matter. Therefore, all that those who were supporting that system wanted was a huge area. Let the power once be given to occupy the cream of those places, whether Parliament gave them a monopoly or not was a matter of very little concern. If they could work the good bits on favourable terms, it would not be very easy to dispossess them of their strongholds by companies coming in on no more favourable terms. They could take the whole cream of London lighting and defy competition. That was an absolute abandonment of the policy of the 1883 order. His clients stood by that policy. What they wanted was that they should have a piece fairly to themselves, that they might work on the direct supply not very far from the generating stations, and they were willing to take the rough with the smooth—to bear the burden of lighting where it was profitable and less profitable, provided both cases were in the same area. If they were going to do that, and do it at a fair and reasonable price, it must be on those terms, that no competition be allowed where a company was doing its work well and complying with all the regulations of the Board of Trade. He thought he might say, without any hesitation, that in saying so he was only repeating the arguments which in 1883 the Board of Trade thought were conclusive in favour of districting as against competition. He would show how that body decided in favour of districting as against competition, and why his clients protested against the latter. Of all the industries that could be mentioned, he should think that there was none in which the gross of production was so intimately connected with the amplitude of demand. Electric lighting in small quantities was an exceedingly expensive luxury, but the larger the demand the smaller became the actual cost at which electricity could be produced. If they were to examine the balance-sheets of electric lighting undertakings it would be seen that the coal bill or the covering to the mains did not constitute anything like the major part of the cost of production—such as maintenance, supervision, and a variety of other things. But with regard to the use of their plant it was all important, if it was to be economical that the demand should be large in proportion to the plant so that it should be fully occupied, and all through the evidence that was given in 1882-3 it was shown that every electrical engineer who had any experience said that the condition of economical supply depended very largely upon the demand. Let them consider for a moment the position of the public in the matter; electricity, no doubt, had got a tremendous rival in gas, capable of supplying light without seriously crippling itself as regarded price. He felt that if electricity had to compete with gas on that score there was no doubt they had a very difficult struggle before them. He quite agreed that where there was only one company there was not that influence in lowering prices that they would have where there were two. But he contended that with even the moderate supervision of the Board of Trade, of the local authority, and the public, no electric company could make exorbitant profits. It would not dare to do it, because if it increased its price there would be a pressure of public opinion which would force the company to reduce it. There was no reason why an electric light company should not be willing to supply electricity cheaply, because by doing so it would immensely diminish the cost of production with the demand for it, and therefore it would have a strong stimulus on business grounds to lower the price. What they wanted was that kind of dealing which the Board of Trade thought fairest to everybody. They were prepared to take clauses which would compel them to do their work. They were prepared to have provisional competition, to take their order under a distinct understanding that if they did not do their duty others would be allowed to come in. They wanted that the Board of Trade should give to each company an area by itself of moderate size in which it could perform its duties at a reasonable price, and give a good service to the public, but let it do that unhampered. Let it have a fair field, and in a year or two, when things were no longer in project, but in actual working, it would be seen which system was the best. Whatever system was the best, all the others must adopt it if they were going to do their work thoroughly; otherwise competitors would come in. Let them not permit the electric lighting of London to be spoiled by immense concessions to companies which would be enabled to take all the good spots, and not to do it thoroughly, and which would commit them to a system which was by no means good to the consumer, because it would be granted upon terms which would render it almost impracticable for better systems to be introduced, except on ruinous terms of competition, rendered so by the unfair advantages asked for by those who sought to get enormous areas. On behalf of the direct supply, he put it before the inspector that it was of the very highest importance that orders should be granted to his clients and to those who, in fair-sized areas, were going to try that method of supply because it was unquestionably the best. That sounded a rather strong statement. Taking the evidence, it was admitted it was the best—that it alone was capable of being used with equal advantage for lighting, but with infinitely greater advantage for motive power, and he stood upon this that it was openly admitted by Lord Crawford and his other witnesses that they considered that motive power would be more important in the immediate future, and a greater demand for it than for lighting purposes. It was not only better but cheaper, and the only method by which they could avoid instantaneous extinction, and the only one in which there was anything to rely upon. No suggestion had been made as to any other method of obtaining that except the direct. The very properties that made it so much the best by virtue of there being storage in it were the very reasons for its being cheaper. People who had really experience in electric lighting would tell them that the curve of demand was an extraordinary one. The demand was exceedingly low until they came to a certain period of the day depending, of course, on the time of the year. When London was not befogged the curve ran up only to a certain height, but when it was befogged it went up in an extraordinary way, with the consequence that a great demand lasted for a time varying from 20 minutes to two hours. All those methods in which they made use of the electricity at the moment they made it were obliged to deal with the apex of that demand, and to be ready not only to perform that at the moment, but must have all their reserves at hand ready to compete with it. In fact, it was scarcely too much to say that with everyone of the systems put before the inspector up to that time, it would want the same plant for the maximum demand only for that comparatively short period of the day that it would want for the steady demand through the whole of the 24 hours. The moment they introduced storage batteries the whole of the demand need not be provided for in their generating plant. Whether they supplied from storage batteries or not, during the whole of those hours they could be using stores that had been piled up during the day; and if they combined the direct supply with storage they could have all their machines working, and all their batteries discharging during those hours, and, consequently, easily meeting every demand. With the direct supply they could feed into their mains at any point. In other words, they could connect their whole network together, and they might have any number of generating stations, or units in a station, and could utilise them for keeping up a uniform pressure at different points of the network of mains, thus securing the maximum advantage. If there was a break-

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down anywhere, the whole of the rest of the generating plant would be *in situ* for the purpose of minimising the effect of that partial collapse of one feeder. In other words, they had *solidarité* throughout the whole system. Another advantage was that it was far the safest. He could not help thinking that the proposal of the London Electric Corporation not to keep their 10,000 volts current down at Deptford, but to send it round London within a half-inch main, was fraught with considerable unknown dangers. Now, his company stood in this position, that not even their enemies said that there was a lurking danger in their system. He agreed with Sir William Thomson that the difficulties in connection with any process were not insuperable, but in such cases the proportion of failures was proportionate to the difficulties. If he could show that their system was better, in that it gave a better supply, in that it was really cheaper, and in that it was safer, he thought he could put before the inspector grounds why he should, on behalf of the Board of Trade, assist his (Mr. Moulton's) clients in getting areas in which they could fairly under such circumstances, show how best they could do their duty to the public, and render the service they wished to do, and why the Board of Trade ought to use its influence with the Legislature in the way of supporting those claims.

Mr. R. E. Crompton was then called and examined by Mr. Moulton. He deposed that he had given great attention to designs for central stations. He had designed and carried out installations at Vienna and Le Mans, besides a central station at Kensington, all of which had worked satisfactorily. From his point of view the first thing that struck a designing engineer with regard to the direct supply with batteries was that it did not break down. It enabled the engines to be rapidly stopped, started, and exchanged during the time of heavy load without the public being aware that such changes were taking place. It was all very well to say that with the direct system without batteries similar things could be done. When the public got accustomed to a little flicker in the light that might be urged. But safety to the public he judged by results. The central station at Vienna supplied two of the largest theatres in the world, and he might say that the authorities there were now more anxious as to panics than they were in any part of the universe. The confidence that had been inspired in those authorities by the use of the electric light from the storage system had been such that all other means of lighting had been dispensed with. The nature of the demand in London varied, but he could describe it in residential London, which he took to be a very large part of the area. It was very little during the small hours of the night, and in winter from 8 o'clock a.m. to 3 o'clock in the afternoon. During the remainder of the time (that was from 3 o'clock in the afternoon to 7 o'clock) there was a rapid increase of load. If the load were represented by a diagram, it would mount so rapidly as to become like the slope of a very steep mountain. After 7 o'clock it suddenly descended to a point of about 60 per cent. maximum. There was a period between 8 and 10 o'clock, when there was a more level fall of the curve. Then it descended very speedily to 1 o'clock in the morning, after which there was a level line up to six in the morning, when the light began in winter. He found that there were about three hours of load at an average of 70 per cent. maximum, and 21 hours load of an average of only 4 per cent. maximum. That 4 per cent. would be distributed over something like six hours. That enabled them to make a large saving in generating plant. They tried to arrange that the engine and dynamos should run as near the full load as possible, in order to get the maximum of efficiency in units per pound of coal. The charge that went into the batteries was a low-tension one. The batteries were parallel with the dynamos. As to the cheapest mode of supplying house-to-house lighting in London, supposing it to be largely used, in his opinion, after careful calculation, there was no advantage in departing from the direct supply—he meant the ordinary well-known three-wire system designed by Dr. Hopkinson, and used in connection with storage. He had made every enquiry as to the transformer system, and he believed, as regarded the cheapness of supply, that there was no advantage in that system if they were lighting a close area. But his knowledge with regard to it was largely at second-hand. One condition, as he understood from Mr. Ferranti's evidence, was that by that system one had to keep an empty engine running to meet contingencies, which seemed to be extremely wasteful, especially when they were working at loads which formed a small percentage of their total. They would work most cheaply at their full load. Certain well-known makers of engines absolutely forbade running their engines lightly loaded. The most convenient unit area for supplying would be about half a square mile from each generating station, each of the latter supplying three to four distributing stations if they could be easily obtained. There was no great advantage in giving a large area unless the cost of the generating stations were very high. The cost of carrying a main sufficient for the distribution of about half a square mile for 2,000 yards, which would be the average distance from a wharf site, would be about £5,000, which would have to be added on to the capital charge.

SATURDAY, APRIL 13.

Mr. R. E. Crompton's examination, continued by Mr. Moulton. Witness said that, speaking as an electrician, he thought that the difficulties met with in practically carrying out underground mains for the distribution of electrical energy were increased in proportion to the E.M.F. employed in the mains, and that whereas in America extended practice had shown that those difficulties were not insurmountable, and dealt with satisfactorily every day so long as the pressure did not exceed 240 volts—the limit employed in the Edison three-wire system—yet the difficulties were so great that they had not been satisfactorily dealt with when the pressure arose to 1,000 volts, and of course the difficulty would be greater when 2,400 volts were used. The Edison system, as a rule, was worked with overhead mains. At Kensington he never cut off the electricity in order to make connections. The pressure was on constantly day and night. He believed that with high-tension mains it would be necessary to cut it off. He could not see how it was possible for men to work with a pressure of 1,000 volts. He had tried all the ways of running mains in pipes, and there were serious difficulties in the way proposed by Mr. Gordon of running several mains into one pipe. When it was necessary to withdraw a main from a pipe, it was necessary to withdraw them as a whole, as the Post Office did with telegraph wires.

Cross-examined by Mr. Pember, he said it would be an inconvenience to those who had the light taken off if it were necessary to take off the high pressure in order to make joints. He had not been in America, and was aware that there were 100 miles of mains there where arc lights were being worked with 2,000 volts, but was not aware that they worked satisfactorily. He admitted that they had been working for a short time. What he meant by saying that was that the cost of the up-keep was so great that they could not earn a dividend. It was a question of commercial, not of scientific, result. He had heard that Mr. Ferranti's system was at work in Nancy, where they were working at a pressure of 2,400 volts.

Mr. Pember: But surely that is an answer to your objection? What is your experience of working at that pressure?

Witness said that he had none.

Mr. Pember: While we are on the subject of the mains, let me ask this. You have spoken of the difficulty of making T joints on mains with the high pressure of 10,000 volts that we propose to employ. There won't be any joints at all on the main trunk lines.

Witness: Excuse me; I never imagined that.

Mr. Pember: That disappears?

Witness: Yes.

Mr. Pember: Then the only question is the making of T oints where the pressure is to be 2,400 volts?

Witness: That is so.

Mr. Pember: Are you not aware that we are working now with 2,000 volts?

Witness was not aware. With regard to the joints that would be on the mains they would be straight running joints, and the danger he suggested was that there would be a leakage at certain points, say, a mile from the works, and the result of the leakage would be that a "burn-out" would take place, resulting in the setting up of a short circuit between the works and the point of leakage, and that would result, of course, in enormously increasing the force of the current in amperes. It would be very difficult for him to say what the leakage would increase the current to, but it would be enormous for a short time. As a contractor he had had experience of both the alternating and transformer systems, and he believed he was in as fair a position to judge of their comparative merits as anybody else. He was most anxious to be fair to the alternating system, believing that it had its merits for scattered districts, for which he would unhesitatingly employ it; but for London he had always held the opinion that the concentrated nature of the lighting and the peculiar distribution of the area of lighting were such as to fit it particularly for the direct system employing storage. He had seen the transformer system at work at Salzburg, where there was a large station. It was rather longer than the Brighton station which they visited the preceding day. He said it was impossible for a lamp to burn 10 hours a day, and he might say that the question of the number of hours that lamps burned was the most important of all in the matter of electric lighting. He had calculated that his own lamps burned 1·1 hours a day. He believed that Mr. Ferranti's evidence on the point of the consumption of coal was based on the supposition that the lamps could burn 10 hours a day—which was an impossibility. The depreciation of the Chelsea cells would be 15 per cent. per annum, or somewhat less.

Cross-examined by Mr. C. A. Cripps, he said that the question of safety with regard to the Metropolitan system was in proportion to the pressure in volts. He had no experience of 1,000 volts, and he could not give an opinion as to whether that would be a safety light or not. His experience was that for 100,000 lights of 10 candles 19 tons of coal would be consumed. As to the cost of accumulators, he should say that if generating plant cost £200,000, the former would cost about £40,000 less. The cost of the distributing mains under his system would not be much more expensive than they would under the alternating. The maximum cost of his mains would be about £1,700 per mile. If the alternating current and transformer system were used instead of the accumulator system, they would have to add 50 per cent. extra on to their boiler and dynamo. He thought that as an engineer there ought to be no difficulty in allowing companies to compete.

Cross-examined by Mr. Shiress Will, he said he preferred the battery to the transformer system. He based his condemnation of the alternating system for London on the fact that, though it had been worked successfully with overhead wires in America, he was satisfied that the difficulties in placing the wires underground would be very great, and would greatly increase the expenses. He had satisfied himself that even in England, in cases where it had been worked with overhead wires, it had been a very costly system. He had only had second-hand experience of working on the alternating system. Of the battery one he had had personal experience. There were three ways in which electricity on the battery system could be supplied. First, a distribution of high-tension current to accumulators in each house; second, the distribution of high-tension currents to subsidiary stations, and then low-tension currents from those subsidiary stations; and third, to have accumulators at the generating stations, and from them distributing by low-tension. The difference in the size of wire to carry 1,000 and 2,000 volts pressure was very great. Theoretically, the wire would have to be 400 times larger in the case of the lower pressure, but it was not so in practice.

Cross-examined by Mr. Wallace, he said that the best area of supply would be half a square mile.

Cross-examined by Mr. Hewitt, he said that he thought it would be necessary to have a subway provided for the four companies in Kensington if there was to be competition, but he did not think it

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would be practicable in High-street on account of the small space. He did not agree to the small area to be allotted to his company and the Chelsea Company.

Re-examined by Mr. Moulton, he said that the deterioration of concentric mains was due partly to electrolytic action. It would be costly to examine them for detecting a serious injury. Theoretically, fuses were as perfect a safeguard for electricity as a safety-valve in boilers. Theoretically, he believed that a boiler or steam-pipe should never burst with a safety-valve. The meters for the direct supply were perfectly reliable.

Mr. F. King (chief engineer to the Electric Power Storage Company) was next examined, and said that he had erected batteries and distributing apparatus at Chelsea from which they obtained a supply of 2,000 lamps of 10 c.p. The method adopted there was that the batteries were separated into two distinct halves. Each half was charged in series from the generating station. While the charge was proceeding to one-half, the other was supplying what lamps might be required, and the process was repeated until, when the two halves had been fully charged, they were both connected in parallel on to the supply mains to give the maximum output from the storage station. A battery could not be on the charging and discharging main at the same time. The tension in the discharging main was 100 volts. He commenced to work in the Chelsea district six weeks ago. They had one battery now supplying light, and another would be ready in a month. Their system was perfectly capable of performing the duties of the undertakers under the provisional order. He believed in what Mr. Crompton had said as to the superior character of the direct supply both for motors as well as for lights, because it was exceedingly steady. He did not believe that it was more costly than the transformer system. He believed, also, with Mr. Crompton, in working their plant with maximum efficiency at full load. Taking into consideration the economical circumstances of the use of plant, he believed that in the transformer and their system the comparative waste would be about equal.

Cross-examined by Mr. Graham, he said that his practical experience of the Electrical Power Storage system covered 2½ years. He had had no experience of it in lighting a large area. There was one generating station in the Chelsea district and three distributing stations immediately proposed. They proposed to send out in all their mains a tension varying from 1,500 to 2,000 volts. He did not anticipate any difficulty with insulation. The charging main would be about 1¼ miles. The discharge in amperes that they proposed to work at was 75 to 100. It might be taken that they would discharge at the former figure. The cells would be in groups of 50, giving out 75 amperes. The size of each cell would be 2½cwt., and the total weight of the cells would be 26 tons for 1,000 lamps of 10 c.p. The cost of each cell erected would be about £5. Of these they had 265, the price of which would be £1,325. He had no doubt about the accuracy of the statement. In Chelsea plant was being laid for 6,000 lamps, to be lighted from batteries alone. For extensions they contemplated using the engines and batteries together. Batteries could be maintained at a depreciation of 12½ per cent. The battery at Lloyd's Shipping House, in which the company had a maintenance contract, cost about 4½ per cent., and it had been running for three years. They had 224 cells there, giving about 500 lights. These lights ran about 1,000 hours per annum. He had advised the Chelsea Company that they could supply the maximum current for seven hours a day. The positive plates in the batteries would wear out in three years. He had never seen a genuinely worn-out negative one. He had seen negative plates seven years old.

In reply to Mr. Lyttleton, **Witness** added that he could not tell the cost of a generating station.

Cross-examined by Mr. Shiress Will, said he considered the battery system to be the best.

Re-examined by Mr. Moulton, he said that he had made a calculation, and he found that they could supply 100,000 lights or more at £2. 8s. per lamp running. The actual capacity of the Chelsea batteries would be 10 hours, and it would be economical to work with them for seven hours.

MONDAY, APRIL 15.

Mr. Shoolbred was first called, and cross-examined by Mr. Moulton. He said that he was now carrying out a central station for the Corporation of Bradford. The decision of the Corporation and himself was arrived at after careful examination of both systems. That which was chosen was the direct current low-pressure system. In his report he presented a comparative estimate of the cost of the direct and of the transformer system, and it was slightly in favour of the latter. He thought, speaking from memory, that there was a difference of £1,000. The one was £20,000, and the other £19,000, the latter being the cost of the transformer system. He considered, taking all circumstances into consideration, that the direct was the better system of the two for the town of Bradford for supplying not only light but power. The Corporation he had mentioned took the matter into consideration, and came to the same conclusion. At present the installation covered a very small part of the town, and was being laid down in conformity with that design for the rest. When they extended the installation it would add to the economy of the present arrangements to add storage batteries to the system, because they could thereby considerably relieve their generating plant.

Cross-examined by Mr. Pember, he said that he had been laying down electric light installations, some of them on a larger scale, for the last ten years. He had laid down some in London as well as in provincial towns. One that was quite as important as any that he had had in hand was that at the Forth Bridge works, which he considered of a more complicated character. Another was at Tate's sugar works at the East End of London. They began originally with a few arc lamps, but they had now 1,000 incandescent lamps. The installation was in one building, and not for the general supply of a large neighbourhood. He maintained, however, that the one at the Forth Bridge had a considerable analogy to a central station, supplying, as it did, a very large area under difficult circumstances, much more varying than would be the case in a central station. Its area was two sides of the Forth, a distance of 1½ miles long, and a quarter to half a mile wide at certain points. The number of lights now supplied there would be about 60 arc and close on 1,000 incandescent lamps. There were three stations—one on either bank of the river, and the other on an island in the middle of it. He had had no experience of the alternating system before he reported to the Bradford Corporation. Some of the members of the Corporation were good electricians, and could judge for themselves. They had visited the Kensington Court and Grosvenor Gallery installations, the merits of both of which were fully explained to them. It was very misleading to speak of an installation by the number of lights. They supplied current, not light: let customers do with it what they liked. The maximum supply for their machines was 1,800 amperes, and they had fixed on 115 volts as their pressure for supplying the town. At present they had three generating units. Each unit consisted of a boiler of 180 horse indicated, a steam engine 115, and a dynamo of 130 e.h.p.—450 h.p. indicated. Bradford was a manufacturing town, with a number of small industries requiring motive power to the extent of 10 to 20 h.p., and therefore the direct system was the best. He had much more confidence in direct than in alternating currents, and motive power ought to be taken into consideration as well as light. He had followed the matter very closely, and had not thought it his duty in any case to recommend alternating currents to his clients.

Cross-examined by Mr. Cripps, he said that there were no accumulators on the system, being merely a direct current low-pressure system.

Cross-examined by Mr. Shiress Will, he added that there were no distributing stations separated from the generating centre.

Mr. W. H. Knight, cross-examined by Mr. Moulton, said he had been an examiner in the Patent Office of the United States in class electricity, and was afterwards with the Brush and Thomson-Houston Company. He was now with the London Subway Company. He said that the points in which the transformer system was inferior were unreliability and the dangers of burning out the transformers, and its lack of economy when working on too small a load, not to mention its irregularity of light. The efficiency practically got was 50 per cent., and it could be worked up to 95 per cent. He thought the pressure quite safe at 1,000 volts. He thought that the Thomson-Houston Company had had a very severe lesson in connection with the alternating motor. He had followed almost every conceivable shape of the alternating motor, some of them being beautiful scientific devices, but they gave no satisfaction. After spending a year on the subject, the Thomson-Houston Company had given it up, and were now more directly engaged with direct current motors than anybody else. They were doing the largest electric lighting business in America as well as the largest motor business. They divided the alternating current business about equally with the Westinghouse Company.

Cross-examined by Mr. Pember, he said that he had had experience in America in regard to the loss of efficiency in the alternating system two years ago. He had heard that there were underground mains in connection with the Grosvenor Gallery working at a voltage of 2,400. With regard to underground mains, he did not say that the joints could not be made perfect.

Cross-examined by Mr. Cripps, he said there were no alternating generators in America over 100 h.p. The pressure in the alternating system there was 1,000 volts, which was thought safe enough. They were there, perhaps, more reckless in that respect than Englishmen. Under that voltage he had had a friend of his paralysed in Pittsburg by putting his hand on the terminals and the switchboard. The danger of burning out the transformers was due generally to leakage through defective insulation. He had had some experience of it.

Cross-examined by Mr. Shiress Will, he said he thought it was possible to work with a pressure of 2,000 volts from the generating machines to the transformers, provided they took proper means for insulation.

Mr. Will: As to the difficulty of working several dynamos at once on the same system with an alternating current, you say it has been done in America, but not kept on.

Witness: Yes; there is a slight difficulty. The dynamos get out of fuse, and while one lags behind it is worked as a motor with the other. They don't keep pace. The difficulty is not to be got over. It has been attempted to work them on the same shaft, and keep up by a mechanical device, but, of course, that makes one machine. Several machines coupled mechanically together are nothing more nor less than one large machine. He added that there were different methods of constructing transformers.

Mr. James Swinburne, examined by Mr. R. S. Wright, said that he was a member of several societies, and had been connected with gas works for some time. The cost eventually must come upon the consumers. The effect of "pirate" companies would be very disastrous because a company like the London or the Metropolitan would, by virtue of choosing all the most paying points in town, be able to undersell the Chelsea Company in Chelsea, and that would hold, even though it subjected itself to the compulsory clauses in Chelsea, because it would have such an advantage in other parts of London. Any deficiency by being under compulsion in Chelsea would be more than made up by lighting the rest of London, so that he thought the London and Metropolitan Companies would have a fair chance of beating the Chelsea Company out of Chelsea. He did not think that electricity was on the same footing as gas when the Gas Acts were passed, because electricity had now to compete with gas, which had its mains laid, and also with petroleum, the production of which had enormously increased recently, so that there was no question of a monopoly even if they gave one electric light company a whole district to itself. Then, again, the waste products of gas had become very valuable lately,

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so that gas could be reduced in price very considerably if necessary. Therefore the competition of gas was sufficient so far as the interests of the public were concerned. With overhead wires, the alternating system for scattered towns with a transformer was a splendid way of lighting. It was much cheaper to use overhead wires if they could. In Boston electricity was cheaper than gas, the latter being 10s. per 1,000ft. The alternating system had the disadvantage that they had to depend on engines and boilers at the station instead of storage batteries at the sub-stations. He did not think storage was at all possible with the transformer system. The loss in transformers was very material when they were put in each house.

Cross-examined by Mr. Pember, he said he was very doubtful whether any electric light company cou'd compete with gas. Gas appealed to a very different public from the electric light, at present, at all events. The poor, who wanted warmth as well as light, would never think of taking the electric light. They would use, probably, petroleum, but the poor might want small electric motors.

Mr. T. O. Callender (manager of Callender's Bitumen Telegraph and Waterproof Company, at Erith), examined by Mr. Wright, said he had had great experience in making and laying underground mains. They had made cables for several hundred different installations. Both at home and abroad he had had experience in laying asphalte paving. In London, especially in the busy parts, there was considerable difficulty in laying anything, the space being already occupied by gas and water pipes, Post Office tubes, cellars, and coal places—all these things made it very difficult. They could not lay their mains close up to gas and water pipes, because the gas and water companies required a sufficient space to be left at the union with a pipe so that men could comfortably get their hands and arms down.

Mr. J. S. Raworth (superintendent engineer of the Anglo-American Brush Electric Light Company), examined by Mr. Wright, said he was also a member of the Committee of Engineers of the Chelsea Electricity Supply Company. They had to do with the alternating system in this respect that they had to manufacture an alternating-current apparatus on a fairly large scale. The Chelsea Company had erected a building at Draycott-place 127ft. by 41ft. 10in., with a basement for engineer and boiler purposes. The ultimate capacity of the station was 25,000 lamps. On Mr. Crompton's estimate it would be 52,000 lamps fixed, the relation between lamps fixed and those in use being two to one. He saw no reason to quarrel with Mr. Crompton's estimate.

Cross-examined by Mr. Pember, he said that the Brush Company were large shareholders in the Chelsea Company, and he believed that a part of his contract had been paid for in shares of that company.

Cross-examined by Mr. Lyttleton, he said that as regarded the Chelsea station the cost of the engines, dynamos, and boilers was £6,500.

Cross-examined by Mr. Shiress Will, he said that in the first instance they proposed to work entirely from the batteries—that was to say, in the early part of the day they charged up their batteries first one part and then the other part, and when the heavy part of the lighting came on at 3, 5, or 6 o'clock, according to the time of the year, they stopped the engines and put the two batteries in parallel and worked on to the lamps. The time during which the batteries gave out light did not exceed seven or eight hours. They would not put down the transformers until they had reached the full working capacity of their batteries—possibly in the course of two or three years. It was a continuous current transformer. They carried the direct current from the generating apparatus into a machine called a motor, and thence into a dynamo, which produced the low tension. The motor was connected to its centre of rotation, which generated currents at 100 volts. That entailed two losses—one in the motor and one in the dynamo, of from 20 to 25 per cent. It was a residential district they were dealing with. They did not propose to put down the transformers until the demand exceeded the supply of the batteries as originally designed.

Major-General Webber (managing director of the Chelsea Electricity Supp'y Corporation), examined by Mr. Wright, said he had had nine years' experience, having been divisional engineer for the Post Office for the East and South of England, including part of the metropolis, from 1870 to 1879. He had laid down a great many miles of electrical conductors in the telegraph service. He had also laid down several lines for the City of London and other places. His attention during that time had been chiefly called to the improvement of the system of distribution, subsequently to that period in connection with the distribution of electricity for electric lighting purposes. In 1883 he drew up a scheme for electric light distribution in the north-east of the parish of Chelsea. He also patented a system of laying copper conductors in iron cases. In 1884 he purchased the rights of the existing tenants at the central station in Draycott-place, and in the same year a syndicate was formed. In June, 1885, on his return from Egypt, statutory notices were issued for a provisional order, which was granted by the Board of Trade and confirmed by Parliament in September, 1885. The original area of supply was in the Hans Ward, and included 660 houses. The gross earning per lamp which he had studied in all parts of Europe varied enormously, but the average earnings of 27 lamps per house would be less than £27—between the two figures. He calculated that when they were supplying 10,000 lamps in use, running the maximum at the busiest hour, they ought fairly to earn a net profit of 10 to 12 per cent. free for dividend. The Chelsea capital was in no way "watered." There had been no promotion money—no preliminary expenses. They all agreed about the Act of 1882. An overhead line in London required very little capital—a few hundred pounds would do it. There were some wealthy houses in Chelsea, but a comparatively small number. He believed that the Grosvenor Gallery made an attempt to go overhead into Chelsea, and there was a petition got up in the parish against overhead wires signed by a large number of influential people. He highly approved of that petition.

PHYSICAL SOCIETY.—April 13.

Prof. Reinold, President, in the Chair.

Messrs. J. E. Dowson, W. M. Mordey, E. A. O'Keefe, C. Priest, A. Siemens, and W. B. Willans were elected members.

Mr. Shelford Bidwell, F.R.S., showed **"A Lecture Experiment illustrating the Effect of Heat on the Magnetic Susceptibility of Nickel,"** and **"An Experiment showing an Effect of Light on Magnetism."** In the first experiment a piece of nickel was attached to one side of a copper pendulum bob, which was held out of the vertical by bringing the nickel in contact with a fixed magnet. On placing a spirit-lamp flame below the nickel the bob was (after a short time) released, and oscillated until the nickel had cooled, when it was again attracted and the operation repeated itself. The second experiment had been recently shown before the Royal Society. One end of an iron bar which had been magnetised and then demagnetised was placed near a magnetometer needle. On directing a beam of light on the bar an immediate deflection of the needle resulted, and on cutting off the light the needle promptly returned to near its initial position. The direction of magnetisation induced by the light is the same as the previous magnetisation, and the bar seems to be in an unstable magnetic state. That the effect is due to light and not heat the author thinks is rendered probable by the suddenness of the action.

The **President** said he had tried the experiment himself, and failed to get any effect; but after seeing the arrangement of apparatus used, he believed his non-success due to the comparatively great distance between his bar and needle.

A **Member** asked if the results were different for different coloured rays, and **Prof. S. P. Thompson** enquired whether the magnitude of the effect varied with the intensity of illumination as in selenium, and also if any change was produced by altering the direction of vibration of the incident light?

Mr. G. M. Whipple wished to know whether any difference was produced by blackening the bars, and as bearing somewhat on the same subject mentioned an induction magnetometer in which an iron bar used was demagnetised by plunging in hot water. The results obtained were very irregular after the first magnetisation, and this may have been due to the instability shown to exist by Mr. Bidwell's experiment.

In reply, **Mr. Bidwell** said red light produces most effect, and blackening the bar makes the action much slower. As regards selenium, the character of the effect is similar, but he believed the causes to be different. Polarised light produces no change. In answer to Prof. Herschel, he said that any part of the bar is sensitive to light, and showed that illuminating both sides of the bar increased the effect.

Mr. G. M. Whipple read a **"Note on the Dark Flash seen in some Lightning Photographs."** After expressing his dissent from the explanations offered in the report of the Lightning Flash Committee of the Meteorological Society and Prof. Stokes respecting "ribbon lightning" and "dark flashes," the author described some experiments he had made on the subject. Ribbon lightning he conceived to be an effect produced by taking the photographs through windows, and to test this, lines on a blackboard were photographed; first direct, second through good plate glass placed obliquely, and third through window glass, the result being that double, triple, and ribbon flashes were closely imitated. As regards "dark flashes" the author believes the appearance due to the prints being taken in oblique light, and to be produced by successive reflection from the reduced silver, forming the dark line on the negative and the upper surface of the glass of the negative.

Prof. Perry suggested that this might be easily proved by examining a negative the prints from which show the dark flash.

Mr. Bailey pointed out that if the explanation given were correct, the dark line should be parallel to the bright one, and this he understood was not always the case.

Mr. Boys remarked that one dark flash exhibited minute wriggles not seen in the bright one, and **Mr. C. V. Burton** thought these might be due to irregularities in the upper surface of the negative.

Dr. Gladstone said he was not satisfied with Prof. Stokes's nitrous oxide explanation, but thought the phenomenon may be due to some kind of reversion. He also mentioned that a negative might probably be obtained from Mr. Shepherd, of Westbourne-grove.

As regards "multiple flashes," **Mr. Boys** said he had often seen seven or eight flashes traverse the same path in rapid succession.

On the motion of the President, the discussion was adjourned until next meeting, when Mr. Whipple hopes to exhibit the negative referred to, together with photographs of his experimental dark flashes.

"On Quartz as an Insulator," by **Mr. C. V. Boys, F.R.S.** In making quartz fibres the author observed that the ends of fibres broken during the shooting process coiled up into screws, and projected themselves against anything brought in their vicinity. After a short time they released themselves, and sprang back to their original position. This could be repeated indefinitely, and the only explanation he could think of was that the fibres were electrified. If so, then to exhibit such phenomena the insulating qualities of quartz must be very great, and experiments were shown to demonstrate this deduction. A small pair of charged gold leaves were suspended from a short quartz rod in a moistened atmosphere, and the deflection fell one quarter the original amount in about five hours. A clean glass rod under the same conditions would discharge the leaves in a few seconds. Dipping the quartz into water did not seem to diminish its insulating properties, and ordinary chemicals produce no permanent prejudicial effect. The author considers that quartz will be very useful in electrostatic apparatus, for the troublesome sulphuric acid may be dispensed with.

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NEW COMPANIES REGISTERED.

British Tanning Company, Limited.—Registered by Sanderson, Holland, and Adkin, 46, Queen Victoria-street, E.C., with a capital of £70,000 in £1 shares. Object: to carry out an agreement, dated April 2, between E. Worms and J. Balé of the one part and H. Hodges, as trustee for the Company, of the other part, for the acquisition of certain letters patent for Great Britain and Ireland, granted to the said E. Worms and J. Balé for an invention for an improved process for tanning by the aid of electricity. The first subscribers are:

	Shares.
H. Hodges, 17 and 18, Basinghall-street, E.C.	1
A. Hodges, 23, St. Swithin's-lane	1
D. C. Lee, Thame, Oxon	1
H. Howse, 4, Comberton-road, Clapton	1
R. W. Rards, 46, Queen Victoria-street, E.C.	1
S. Pailthorpe, 1, Courthope-road, Hampstead	1
W. R. F. Livosey, 52, Queen Anne-street, W.	1

The number of Directors shall not be less than three, nor more than seven. The first to be appointed by the subscribers to the memorandum of association. Qualification, 250 shares. Remuneration, £800 per annum, and further 5 per cent. on the net profits after payment of 10 per cent. dividend.

Sante Fe Northern Railway Company, Limited.—Registered by Ashurst, Morris, Crisp, and Co., 6, Old Jewry, E.C., with a capital of £675,000, divided into 4,500 preference shares of £100, and 2,250 ordinary shares of £100 each. Object: to acquire, construct, complete and equip, maintain, prolong and work railways, and their appurtenances, tramways, lines of telegraph, telephones, or other means of communication, or appliances of a similar nature, in the Argentine Republic. The first subscribers are:

	Shares.
J. B. Went Henry, 16, Down-street, W.	1
C. W. Bloomfield, Acton	1
A. P. Baker, 135, Gladstone-road, Wimbledon	1
J. A. Holliday, Sudbury Villa, Asylum-road, Peckham	1
H. Hall, 89, Westmorland-place, City-road	1
J. B. Gelder, 115, Petherton-road, N.	1
E. F. Botwright, 23, Sutton-place, Hackney, E.	1

The number of Directors shall not be less than three nor more than seven. Qualification, £500 preferred shares. The first to be nominated by the majority of the subscribers to the memorandum of association. Remuneration, £2,250 per annum, payable quarterly, to be divided as the Board may determine.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts of this Company for the week ended April 19 amounted to £2,179.

West India and Panama Telegraph Company.—The traffic receipts for the half-month ended April 15 show an increase of £720 as compared with the corresponding period.

Western and Brazilian Telegraph Company, Limited.—The receipts for the past week, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, were £1,057.

Great Northern Telegraph Company of Copenhagen.—This Company for the year 1888 state that the total receipts, including the balance brought forward, were £329,119, the expenses being £64,440. The Board propose the transfer for reserve and renewal fund of £55,555, and, after paying interim dividends amounting to £75,000, recommend a final dividend which will absorb £37,500, making a total of 7½ per cent.; the balance to be carried forward being £41,346. The investments during the past year on account of the reserve and renewal fund amounted to £37,218.

PROVISIONAL PATENTS, 1889.

APRIL 15.

6400. **The transmission of power from a motor engine to machinery or to another, or other, motor engines.** George Pinnington, 23, Chichester-street, Chester.

6410. **Improvements in galvanic cells for telephones.** Robert Acton Burnell, 101, Bishopsgate-street, London. (Theodor Wilms, Hamburg.)

6416. **An improvement in electrical contact makers or switches or connectors for the passage of a current of electricity.** Harry Scott Nowell, 47, Westcroft-square, Hammersmith.

6423. **Improvements in electrical motors and apparatus connected therewith, especially applicable to purposes of locomotion.** Alfred James Jarman, 4, Little Moorfields. (Complete specification.)

6429. **An improved electric apparatus.** Charles Wells, 22, Southampton-buildings, Chancery-lane, Middlesex.

6458. **Method of regulating the electric current produced by an electric machine driven by a motor having an irregular or variable speed.** Paul Hoho, 323, High Holborn, London.

APRIL 16.

6527. **Improvements relating to electro-motors.** Henry Harris Lake, 45, Southampton-buildings, London. (Nikola Tesla, United States.) (Complete specification.)

6544. **Improvements relating to electric incandescence lamps.** Albert Augustus Goldston, 4, South-street, Finsbury, London.

6547. **Automatic circuit-controllers for electric circuits.** Stanley Charles Cuthbert Currie, 24, Southampton-buildings, London. (Complete specification.)

APRIL 17.

6553. **An electric energy meter.** Sir William Thomson, 115, St. Vincent-street, Glasgow.

6557. **Improvements in cut-outs for electric circuits.** John Nealor Cooper, 5, Paignton-road, Stamford Hill, London.

6568. **Improvements in dynamo-electric generators and motors.** George Edensor Dorman, The Hawthorns, Stafford.

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6571. **Improvements in dynamo-electric generators and motors.** George Edensor Dorman, The Hawthorns, Stafford.

6572. **Improvements in dynamo-electric generators and motors.** George Edensor Dorman, The Hawthorns, Stafford.

6579. **A combined insulator and finial and lightning wire for telephone, telegraph, or other electric wires.** Hubert Feilden Jackson, Alfred Coleman, and Patrick Loftus, Prideaux Chambers, Change-alley, Sheffield. (Complete specification.)

6609. **Improved method and means of obtaining electricity.** William Boggett, 34, Southampton-buildings, London.

APRIL 18.

6622. **Improvements in electrical switches, fuses, cut-outs, ceiling-roses, lamp-holders, and the like.** Frank Geere Howard, Joseph Appleton, William Thomas Burbey, and Albert Edward Williamson, 91, Queen Victoria-street. (Complete specification.)

6628. **Improvements in laying and insulating mains for conveying electricity.** William Harding Scott and Laurence, Paris and Scott, Gothic Works, King-street, Norwich.

6654. **Method of employing magnetism in connection with locks for boxes, doors, and the like.** Iwan Bolaschoff, 41, Eastcheap.

6675. **Improvements in electrically-driven fans.** Henry Garwood Watel, 28, Southampton-buildings, London.

APRIL 20.

6713. **Improvements in electric lamp fittings.** Wilson Henry Sturge, 12, Cherry-street, Birmingham.

6728. **Improvements in the method of and means for the distribution of electrical energy by alternating currents.** Gisbert Kapp, 70, Market-street, Manchester.

6745. **Improvements in the method of and means for electrolysis of substances in a state of fusion.** Martin Kiliani, 46, Lincoln's-inn-fields, London.

SPECIFICATIONS PUBLISHED.

1888.

6382. **Electric automatic delivery box.** Miller. 8d.

6876. **Measuring electric currents.** Aron. 8d.

7111. **Electrical couplings.** Davies. 8d.

7720. **Electric tell-tales.** Boardman. 8d.

7876. **Electric batteries.** Willcox (Abakanowicz and another). 8d.

8039. **Generating, &c., electric currents.** Le Clercq and Vansteenkiste. 8d.

9381. **Electric batteries.** Imschenetzky. 8d.

12198. **Electrical switches.** Schmidt. 8d.

12817. **Electrically stopping steam-engine from a distance.** Dixon. 8d.

1889.

485. **Electric generators.** Newton (Piedrahita). 6d.

3373. **Galvanic ear appliance.** Munro. 6d.

3401. **Dynamo-electric machines.** Sperry. 8d.

3456. **Electric circuit couplers.** Currie. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	18
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply ...	5	3¾
......	...	Swan United	3½	2¾
12 July	12/0	Telegraph Construction ...	12	42
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15½

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NOTES.

Continued.—The Gas Company of Malaga has now hauled down its colours and surrendered.

The Argentine Republic.—A 30,000-light Edison station is under way for Buenos Ayres.

Reading.—The gas was put out last week at Reading to see the effect of the electric light alone, and the members of the Corporation went round to inspect the lighting.

The Electric Light in Austria.—The municipal authorities of Bilin (Austria) have, we are informed, definitely decided to adopt a system of street lighting by electricity at a cost of about £2,400.

Electric Fire Alarms at Crewe.—The question of providing electric communication with the firemen has been brought forward at the Crewe Town Council, but the matter is adjourned for the present.

Conversazione.—We are informed that the President of the Institution of Electrical Engineers and Lady Thomson are about to issue invitations to the members for a *conversazione* on Friday, May 24th.

Personal.—Mr. Arthur W. Slater has withdrawn from partnership in the Galway Electric Company, and has transferred his interest therein to Mr. James Perry, who assumes all liability in connection therewith, and continues the business on his own account.

Telegraphs in Sweden.—The new tariff, equal to 7½d. per message, for local messages, which has been in force since the commencment of the year in Sweden, has largely increased the traffic. In many of the towns the increase amounts to more than 50 per cent.

Institution of Electrical Engineers.—The next meeting of the Institution will be held on Thursday, May 9, at 8 p.m., when Mr. Preece is expected to open the discussion on Dr. Oliver Lodge's paper on "Lightning, Lightning Conductors, and Lightning Protectors."

Underground Mains in Paris.—The work of laying the underground mains is going ahead on the boulevards, from the Porte Saint-Denis to the Grand Hotel. The mains are being laid in conduits 1·50m. high by 75cm. wide. They consist of bare cables run on porcelain insulators.

Dynamo Oil.—We have received a list price of specially prepared oils for engine cylinders and dynamos, from Messrs. W. H. Wilcox and Co., 36, Southwark-street. Messrs. Wilcox now issue a special dynamo oil, which is in large demand, for installations, and will send a small sample for trial to those wishing to test it.

Bordeaux.—The proposed installation for the Bordeaux Docks will shortly be carried into effect. It will consist of seven arc lamps (taking 30 amperes) upon the quays and six incandescents in the machine-room. The current will be furnished by two Gramme dynamos of 70 volts and 180 amperes, driven by a 30 h.p. steam engine.

The Telephone Amalgamation.—The *Financial News* understands that the telephone companies have found a way out of the difficulty in the way of their amalgamation created by the Postmaster-General, and that particulars of an amended scheme, to which his assent will not be necessary, will be placed before the shareholders immediately.

Enamel Insulation for Dynamos.—Mr. Benson Bidwell, writing to the *Electrical World*, points out that his patent No. 393,666, November 13, 1888, covers the entire principle of using vitreous material on thin metal sheets or cast metal drums for insulation of bare copper wire for dynamos, intimating that parties wishing to use it can do so on payment of a small royalty.

Lambeth.—The Vestry of Lambeth will consent to the application of the electric companies if they accept certain responsibilities with regard to compulsory lighting of the principal streets, such as Waterloo-bridge-road, Albert Embankment, Kennington-road, Wandsworth-road, Clapham-road, Dulwich-road, and other main roads in the district; otherwise they will oppose their consent to the orders.

Paris.—The new terminus hotel near the Saint Lazaire Station at Paris, appears to have been most comfortably installed. Amongst other things more or less luxurious, each room is provided with an Ader telephone, by means of which the traveller may transmit and make known his desires. The hotel will be lighted entirely by electricity, and we understand the installation will be carried out by the management.

Niagara.—The Buffalo papers, who know more about the behaviour of Niagara Falls than ourselves, suggest that, as the falls are generally frost-bound until far into May, any attempt to utilise the power at the Cave of the Winds, as proposed by Mr. Hamilton, could only result in the whole machinery being solidly embedded in ice, and carried away bodily at the thaw, and condemns any such suggestion as absolute foolishness.

A Gas Electric Meter.—Mr. Walter F. Smith, of Philadelphia, advocates an electric meter illustrated in the *Electrical World*, consisting of a combination of an electrolytic cell and a gasmeter. The gas generated in the cell is collected in a receiver, and is measured by a gasmeter and dials of much the usual kind. This arrangement, though ingenious and novel, would partake far too much, however, of the notorious bad character of gasmeters to be practically adopted.

Inner Temple.—Although the Inner Temple have summarily stopped the elaborate preparations which were being made for a central installation, they have in no way decided to discontinue the use of the electric light. On the contrary, we hear that they have instructed Messrs. Drake and Gorham, who were formerly connected with this work, to carry out the extensions to the existing installation, including the fixing of an 18 unit dynamo and some cells. These will be placed in the existing electric light shed.

Northampton.—An electric light company is in process of formation at Northampton, and we trust that this town, which had so early a try for priority of electric light in England, is now on the way of being really lighted up. Mr. J. W. March, of the Taunton Electric Light Company, who is staying in Northampton, has written to the local paper, pointing out the success of the Taunton installation, and advising those in authority to adopt the Thomson-Houston system, which has proved so satisfactory in that town.

Newington Vestry.—At the last meeting of this Vestry it was moved that no objection be offered to the draft provisional order lodged with the Board of Trade by the London Electric Supply Corporation, or any action

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taken to watch the progress of the order through Parliament. It was generally felt that the Vestry need not move in the matter if the company were able to satisfy the Board of Trade that they were in a position to undertake to carry out the work. The motion was agreed to without discussion.

Barnsley.—At the meeting of the Barnsley Town Council last week, a question arose as to the better lighting of the town. A resolution, referring the matter to the committee, had been passed last October, and Mr. Tinker now expressed his desire to give notice of a motion in favour of the Council enquiring into the desirability of lighting the town by electricity. It was stated that the committee are preparing a report on the subject of lighting, and it was agreed to let the matter stand over until the next meeting.

The Telephone in Spain.—From recent statistics it is shown that 30 towns in Spain possess telephone systems, with a total of 4,585 subscribers, the tariffs ranging from 85 to 300 pesetas—say, £3 to £11—per year. Curiously enough, out of all these concessions 28 are held by private individuals, and only two by telephone companies. These are at Madrid, where the Sociedad General de Telefonos has 1,458 subscribers, and at Barcelona, where the Sociedad Española de Electricidad has 774. The remaining private enterprises range from 433 (at Bilbao) downwards. Madrid telephones have paid 10 per cent. for 1888.

Medical Electrolysis. — Dr. Dujardin - Beaumetz brought before the French Academy of Medicine on the 13th of March a patient cured of constriction of the œsophagus by electrolysis by Dr. Fort. The patient, who came from Nièvre, arrived in Paris on February 16. The œsophagus did not measure more than five millimetres in diameter, and only allowed with difficulty the passage of a few drops of soup. The patient now eats all kinds of food, he has gained 10lb. in weight, and the œsophagus now measures 14 centimetres in diameter. This is the first instance of the application of electrolysis to the cure of constriction of the œsophagus.

Old Students' Association.—A meeting of the City and Guilds Old Students' Association will be held at the Technical College, Finsbury, E.C., on Wednesday, May 8, at 7.45 p.m., when a paper will be read on "The Construction and Maintenance of Secondary Batteries," by J. Appleton, member. The following is an outline of the paper, which promises to be an interesting one: Theory of the secondary battery; brief history of its development; an ideal secondary battery; modern types of secondary batteries, their construction and maintenance; the direction in which improvements are wanted and are likely to be made; maintenance of secondary batteries.

A Smash at Berlin.—The following note on an accident to the Emperor's chandeliers appears in the *Pall Mall Gazette*: "The carrying out of the Imperial decree, 'Let there be electric light,' in the White Salon of the Palace at Berlin, has not been without its grave difficulties. In order to 'fix' the new arrangements, it was necessary to remove the crystal chandeliers to the factory of the electricians. But on its road thither an uncouth butcher's man drove his heavy cart against the waggon on which the chandeliers were being conveyed; there was a great crash, a sound as of a thousand crystal bells, and half of the chandeliers were broken into a thousand pieces."

The Telephone in Austria.—The authorities at Buda-Pesth having accepted the proposition made by the Austrian Minister of Commerce for the installation of direct telephonic communication between Vienna and Pesth, the works will be commenced as soon as the necessary preliminaries are arranged. The Chamber of Commerce of Pilsen has petitioned for a telephone service between its town and Vienna or, at least, Prague. The Chambers of Commerce of Trieste and Fiume have also asked for the establishment of communication by telephone between the two towns. Finally, the Government has authorised the construction of a line of silicium bronze between Trieste and Laibach.

An Inventor's Guide.—We have received a neat little book from Messrs. J. K. Fahie and Sons, of Dublin, members of the Institution of Electrical Engineers, entitled a "Handbook of Patent Law," new edition (London: Spon and Co., 6d.), which is not a mere dry digest of patent rules and charges, as is often the case with similar productions, but a readable little guide for inventors, containing a great deal of information of the kind required by would-be patentees, and some very useful "hints to inventors," or how they should go about patenting, and, what is more to the point, making money of it. We should advise such of our readers who are inventors and inexperienced in patenting to possess themselves of a copy.

Electricity in Cold Climates. — An incidental superiority of electricity in countries where intense cold often prevails is pointed out by Mr. J. Parke Channing, an inspector of mines in Michigan. Mr. Channing is of decided opinion that electricity seems to hold forth a promise to solve many problems in the way of transmission of power that have so far been impossible. He denounces steam underground as a nuisance, a danger, and wasteful, and states that compressed air, as has been demonstrated by careful tests at the Chapin Mine, has a low efficiency. He also specially points out that in a cold district like Lake Superior, where the freezing of steam and air pipes is a constant element of loss and delay, electric power has decided practical advantages on this score alone.

Electric Lighting in Brussels.—M. Somzée, who, it will be remembered, was chiefly remarkable in the past for having united in his own person the interests of both electric and gas lighting, and for whom the honour of being the inventor of the first successful incandescent lamp is yet claimed by a few enthusiastic admirers, has installed the electric light in his own house in the Rue du Palais. The current is supplied from a battery of 100 accumulators, charged by cable from the works of MM. Bouckhaert and Co. The first lighting up of M. Somzée's house took place on the occasion of a dinner at which General Boulanger was present.—The installation at the docks at Antwerp has been added to. It now consists of 48 Jablochkoff lamps (foyers), divided into 12 circuits, supplied by Gramme and Siemens dynamos.

The Electric Light at Brighton.—On Friday last Major Marindin concluded a Board of Trade enquiry with respect to the application of the Brighton Electric Lighting Company for a provisional order under the Electric Lighting Acts, 1882 and 1888, to enable them to extend their system. The Corporation opposed the granting of the order, because they thought that the company was financially insecure, because in detail its scheme was unworkable, and because the order gave the company the right to interfere with the roads for the purpose of carrying their

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lines underground. The Hove Commissioners took a similar view, and their counsel contended that there was no general demand in Hove for electricity, and, if such were to be the case, the Hove Commissioners were thoroughly in a position to cope with the demand.

An Indian Agency.—Messrs. Volkart Bros., Bombay, have just established an Anglo-Indian engineering agency office, which, whilst forming part of the firm, is under the special management of trained engineers of technical education and of practical experience both in Europe and in India. The agency will have for its chief object the import of all and every description of plant and machinery, but will give special prominence to the introduction to India of plant for electric lighting, and for transmission of power by electricity. Branches are already established at Kurrachee, Tellicherry, Calicut, Cochin, Tuticorin, Madras, Delhi, Colombo, and at other agencies in the interior. The London office is at 31, Queen Victoria-street, E.C., and is under the superintendence of an engineer of over twelve years' practical experience in India. An agency of this kind should be highly beneficial in opening out the vast possibilities of electrical engineering in India.

Electrical Hoists for Mining Purposes.—In a report of the Californian Mining Bureau, it is stated that the first application of electricity to hoisting works for mining purposes in the West is at the Veteran Tunnel at Aspen, Colorado. The power is furnished by a Pelton wheel, with governor for regulating the flow of water. The wheel is situated 6,500ft. from where the power is applied, and drives a 500 volt Edison dynamo, which converts into electrical energy 92 per cent. of the power thus developed. The wheel is of 90 per cent. efficiency, and the energy available for work at the motor pulley is 74 per cent. of the water from the wheel. The motor operates a hoist over a shaft 200ft. deep, and also runs a train of nine waggons through a tunnel 1,000ft. in length. Formerly one man was required to each car, taking 20 minutes for the round trip. Now the entire train is run out and returned by one man in eight minutes.

The "Lahmeyer" Dynamo.—We have received from the Deutsche Elektricitäts-Werke (Garbe, Lahmeyer and Co.), Aachen, Aix-la-Chapelle, Germany, an interesting portfolio of illustrations and description of the "Lahmeyer" dynamo. This machine, which is very well known on the Continent and in America, has gained rapid ground for the excellence and simplicity of its construction, and the firm producing it have so many orders that they have been obliged to double their factory and plant. The "Lahmeyer" dynamo is one with double poles returning upon them selves on the outside in such a way as completely to encase the working parts in iron. The result is both great freedom from loss of magnetic lines of force affecting watches or ships' compasses, and also—a most important point in practice—complete protection from exterior damage from knocks or accidental falling of tools or other articles upon the coils. The firm have made arrangements to ship by Antwerp or Hamburg, and in certain situations the well-tested qualities of the "Lahmeyer" dynamo may secure them acceptance on the English market.

A New Open Circuit Battery.—An improvement in the porous cup of the Léclanche battery has been introduced, according to the *Electrical World*, by the National Galvanic Battery Company, of New York, with the object of increasing its life and efficiency. The new cup consists of a vitrified body, which is perforated, and all the cups are perforated alike, so as to obtain uniformity of action. Through the network thus formed the solution circulates freely, and current is available immediately upon the immersion of the cup in the liquid. In addition to the usual lead terminal head is a supplementary piece of platinum wire, which, being unoxidisable, allows the cell to work until the crushed carbon and oxide of manganese is thoroughly reduced. Tests of the battery, made by Mr. John A. Seely, electrician of the Metropolitan Telegraph and Telephone Company, show that after a short circuit of over five hours the current, which was originally one ampere, had still a strength of ·2 ampere. In another test the cell was placed in circuit with a resistance of 150 ohms for over 13 hours, after which it was at once connected with a vibrating bell, which it rang continuously for 137 hours.

Royal Meteorological Society.—At the meeting of this society, held on Wednesday, the 17th inst., at the Institution of Civil Engineers, Dr. W. Marcet, F.R.S., president, in the chair, a paper was read "On the Deaths caused by Lightning in England and Wales from 1852 to 1880, as recorded in the Returns of the Registrar-General," by Inspector-General R. Lawson, LL.D. The total number of deaths from lightning during the 29 years amounted to 546, of which 442 were of males, and 104 of females. In consequence of their greater exposure, the inhabitants of rural districts suffer more from lightning than those of towns. It appears, also, that vicinity to the west and south coasts reduces the chances of injury by lightning, and that distance from the coast and high land seems to increase them. In his paper "On the Rime-frost of January 6 and 7, 1889," by Mr. C. B. Plowright, F.L.S., the author gave an account of the very heavy rime-frost which occurred in the neighbourhood of King's Lynn on these days, when the fringe of ice-crystals upon twigs and branches of trees was about 2in. in length. The weight was so great that nearly all the telegraph wires were snapped and an immense number of branches of trees broken off.

A Large City Plant.—The city of St. Louis, U.S., is to have a very decent electric lighting plant, according to advice just to hand. The cost will be half a million dollars, and the concession has been awarded to the Indianapolis Jenney Company. The plant will be capable of maintaining 4,000 arc lights of 2,000-c.p. each, and 10,000 incandescent burners of the accumulator system. Of the 4,000 arc lights 2,226 will be used for lighting the streets, as stipulated in the contract, and 1,774 for private use in commercial buildings and elsewhere. Of the 10,000 incandescent lights more than 4,000 have already been disposed of. In the construction of the lines over 300 miles of wire will be used. Twenty miles will be placed in underground conduits, and the remainder strung overhead. The revenue from the contract with the city will be 166,439dols. a year, which, together with the receipts from private lighting, will bring about 300,000dols., from which the contractors expect to realise a handsome profit. The construction will give employment for eight months to 1,000 men in various capacities, and when the actual work of lighting begins 250 men will find steady work. The coal consumption will aggregate 100 tons per day.

New Issue of "Brush" Shares.—The Anglo-American Brush Corporation announce the further issue of £75,000 6 per cent. first mortgage debentures in bonds of £50, £100, and £500 each, upon the security of the

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whole assets of the corporation. The debentures will be issued at par, and bear interest at 6 per cent., and will be redeemable at the rate of 105 per cent. on 1st June, 1903. The subscription list is to open to-day (Friday) and close the same day at 4 p.m. An interesting set of curves is sent with the prospectus, showing an advance in volume of business, from the amount in 1883 taken as 100, to 307·4 in 1888, or 356·9 including their continental business. The general charges remain practically the same, including the continental business for the whole period, showing a rise in gross profits to 342·9 English, or 498·8 with continental, as compared with 1883 taken as 100. We are glad to see this increased activity; greater business under these circumstances means greater profit, and greater business is constantly requiring fresh means of manufacture. We note that last year shows an increase of 70 per cent. in the gross profit, with only 7 per cent. increase in general charges, and the corporation have more orders now on hand than at any previous period.

Sulphate of Soda in Secondary Batteries.—The use of soda in secondary batteries, mentioned by Mr. Preece in his paper at the Society of Arts, is rapidly increasing in practice. The object of the addition is to prevent the accumulation of non-reducible sulphate of lead. We note that Mr. Preece has found the addition to work perfectly, and ascribes the invention to an accidental idea of Mr. Barber Starkey. It has, however, been advised on theoretical grounds by several chemists. It was suggested by Mr. Swinburne, at a meeting of the Telegraph-Engineers in 1886, and the theory was explained; we believe it has been used for some time back by Mr. Crompton in his batteries. The action depends on the slight solubility of lead sulphate in sulphate of soda. A little dissolves and is at once electrolysed, the lead being deposited. A little more sulphate is then dissolved, and so on. In cases of rapid charge a little caustic soda may be set free in the immediate neighbourhood of the plate, and dissolve the sulphate. There is obviously no advantage in beginning with the carbonate instead of the sulphate of soda, and the use of the carbonate has the disadvantage of causing a strong ebullition on being thrown in. Now that attention has been called again to the question, we may expect users of batteries to test the action in practice on their own cells.

A Wave Motor.—Water motors, to be worked not by the action of the tide or flow of water, but by the motion of the waves, have been proposed time and again, and specially recommended to the attention of electrical engineers—one in which air was to be compressed by the rise and fall of a heavy hollow buoy was practically tried on the coast line some time ago with fair success. A novel form of wave motor is proposed by Mr. John A. Rowe in the *Transactions* of the North-East Coast Institution of Engineers and Shipbuilders for March, 1889, which may be interesting to allude to. This was designed primarily for the important purpose of enabling a gun to be discharged at the moment of level keel; but the arrangement has developed into a new motor actuated by the rolling effect of the vessel—a force mentioned by the author for a 9,500 ton vessel rolling 30deg. as mounting to 3,000 h.p., though the proposal to recover this enormous power is not contemplated. He does, however, show that with a heavy balanced weight—fitted to a *fixed* piston, the cylinder moving with the ship—66 h.p., or even up to 264 h.p., might be obtained practically from such a ship, a force which might be applied to force water from the ship by pumps, and propel her as the "Waterwitch" is propelled; or air-pumps might be worked by this means for the furnaces or other purposes; and in anchored vessels near land or lighthouses, otherwise to utilise the rolling motion of waves.

City Guilds Institute.—The "Report to the Governors" of the City Guilds Institute of Technical Education, just issued, is exceedingly interesting, and the only regret is that the disappointment in the decision of the Drapers' Company to reduce their contribution to £2,000, being half only of the previous contribution, has resulted in the curtailment of the expenses of the institute in every department, and precludes any further development at present. The total of the students who have matriculated at the Central Institute is now 98 up to September, 1888. An interesting feature of the report is a table in detail giving particulars of the subsequent career of some of the most promising students. The same is done with day students at Finsbury, containing many well-known names in electrical engineering, ranging from assistants at works to full-blown professors. The total of students who received instruction at the Central Institution during the year is 431, including attendance at summer classes. At Finsbury there were 169 day students, and in the evening classes 1,012 tickets were taken by 914 students, 221 of whom entered as apprentices at half fees. The total donations to the institution show a falling off from £27,502 in 1887 to £24,195 in 1888; and this, in view of the spreading sense of the immense utility to England's commercial progress of these institutions, should lead those who have the means to give all help possible to these most advantageous organisations for adding increased productive power to the youth of the present generation.

Electric Power at Work.—It is interesting, says the *Western Electrician*, to visit a factory in which steam is utilised, and to watch the numerous machines in motion, tracing the power to its source from top floor to the engine-room; but it is far more wonderful to enter a factory in which the machines are operated by electrical energy. Here the machines revolve and do their work the same as in the other building, but the visitor is unable to see whence they get the power. In a great many instances the motor is cheaper, and it is always cleaner, and there is a saving in the wear and tear of machinery belting. It is only within the last year, however, that the manufacturers of Chicago have learnt the benefits to be derived from the use of the electric motor for driving heavy machinery. The city authorities did not wish to permit the motor to be run in connection with arc circuits, but numerous successful examples overcame their objections. The Baxter Motor Company undertook to introduce their machines, and numerous users in 18 different classes of establishments are now at work. The Sprague motor is also at work, and is greatly in demand for printers, those now in use ranging from 2 to 25 h.p. One large printing establishment in Chicago recently introduced a 10 h.p. motor, and was so well satisfied that it has been decided to run all the machinery in the establishment by electricity, and new motors will be introduced. The Chicago *Daily Herald* and *Tribune* are printed by electric motors. The C & C motors are also greatly used, principally for driving sewing machines, ventilating fans, and other light machinery.

Faure v. Julien.—The case between the holders of these patents has caused considerable interest in the States. The final result is an interdict from the Court to the Julien

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Electric Company, because they are held to have infringed Faure's patent. The wording of these legal documents is amusing to minds trained in a wider sphere. Fancy the Julien Company—the naughty boy—corrected in the following language, which, however, is effective, if not idiomatic: "Now, therefore, we strictly command and enjoin you, the said the Julien Electric Company, and your officers, associates, and your clerks, agents, servants, and workmen, and each of you, under the penalties that may fall on you and each of you in case of disobedience, that you and each of you forthwith and for ever desist from directly or indirectly making or causing to be made, using or causing to be used, or vending to others to be used in any manner, any polarisation or secondary batteries containing or embodying the invention described and claimed in said first claim of said letters patent, as so limited by said disclaimer, to wit: Any polarisation or secondary batteries containing or embodying an electrode consisting of a support coated on one or more faces, with an active layer of absorptive substance such as metal or metallic compound, applied thereto in the form of a paint, paste, or cement, and practically insoluble in the electrolytic liquid so as to be or instantly become spongy, and thus capable of receiving or discharging electricity, as stated in said letters patent, and from vending to others to be used, or using or causing to be used in any manner, any secondary or polarisation batteries, thus heretofore constructed by you or any of you, and from infringing the first claim of said letters patent, as limited by said disclaimer, in any way whatsoever. Witness, the Hon. Melville W. Fuller, Chief Justice of the Supreme Court of the United States, at the City of New York, on the twelfth day of April, eighteen hundred and eighty-nine."

The Lighting of Chelmsford.—Although the exact details of the public lighting of Chelmsford have not yet been finally settled, Messrs. Crompton and Co. have the machinery well in hand and much of it is now ready. The town is to be lighted, as at present arranged, with 20 arc lamps and 110 incandescents of 32 c.p., and the town councillors of Chelmsford visited Messrs. Crompton's works last week to witness the trial of two of the incandescent lamps. The lamps were Edison-Swan lamps, 32 c.p., and were fixed to the wall of the works by iron brackets at a distance of 45 yards, each mounted in lanterns of different shapes. At 9 o'clock the light was turned on and proved most satisfactory. The lamps were moved to a distance of 70 yards apart, the average distance apart in the town, and again the lighting between the lamps was most satisfactory, being very much better than the adjacent gas lamps,; some of the councillors even suggesting the exclusive employment of these lamps as cheaper than arc lamps. The members of the Council then went through the town to settle upon the position of the lamps in the streets. At the Town Council next day the Lighting Committee presented a report as a result of their labours. After recalling the fact that Messrs. Crompton and Co. had undertaken to light the town by means of 20 arc lamps and 110 incandescent lamps for the annual sum of £700, the report stated that Messrs. Crompton had informed the committee that they should not require the use of the present gas lamps and standards, as they intended to provide their own lamp-posts. This, continued the report, put an entirely new complexion upon the question, and the committee felt at once that they were in a position to remodel the lighting of the whole district. It would be in the recollection of the Council that the total number of gas lamps was 188. Deducting 110 to be replaced by the incandescent lamps, it left 78 as the number superseded by the 20 arc lamps. But the Council a short time back resolved to add 14 gas lamps in different places, this making 124 lamps to be dealt with. The committee arrived at the conclusion that the arc lamps should be confined to the main road through the town. This absorbed 18 arc lamps, leaving a further margin of 18 incandescent lamps to be dealt with, or a total of 142. It was found that the distribution of lamps was very unequal in different parts of the town, being sometimes 50 to 60 yards apart, while in other places they were 110 yards apart. The committee, after seeing the experiments at the Arc Works, had come to the conclusion that if the incandescent lamps were placed about 70 yards apart the roads would be well lighted, while in roads where the traffic was not so great the distance might be increased to 100 yards. The committee determined to adopt this as a sort of standard, and, starting on this basis, it became manifest that a much larger number of lamps than were at the disposal of the committee would be required in order, as far as possible, to equalise the lighting of the whole district. They accordingly determined to lay before the Council a scheme which, although entailing some additional expense, would nevertheless recommend itself to the Council as dealing with the whole question in an equal and fair manner. The report stated that the result of the whole scheme was that the committee recommended the adoption of 18 arc lamps and 200 incandescent lamps. It had been arranged that the price of the arc lamps should be fixed at £22. 10s. each per annum, and the incandescent lamps £2. 6s. 10d. each per annum. The result would be: 18 arc lamps at £22. 10s. each, £405; 200 incandescent lamps at £2. 6s. 10d. each, £468. 6s. 8d.; total, £873. 6s. 8d. Under the old contract, the Council were paying £768 for gas lighting, and the 14 additional lamps would have added £56, so that the total cost would have been £824, and even at the reduced offer of the gas company, £3. 4s. per lamp, the cost of the scheme with gas would be £832 for lamps consuming 4½ cubic feet per hour, as against an equal number of incandescent lamps. If the Council determined to adopt their recommendation, the Lighting Committee were very strongly of opinion that the whole town would be lighted in a very superior manner to any provincial town of equal size, and, as it could not be questioned that the efficient lighting of a town not only conduced to the comfort of the inhabitants, but to the protection of property, the committee very urgently recommended the adoption of this scheme. The draft contract, which had been drawn out, was also read. The lighting is to be entered upon on the 9th of September next, and at any time during the five years over which the contract extends the Council will have power to terminate the contract if they consider the lighting is inefficient. There will be a fine of fourpence an hour for every arc lamp which goe out, and one halfpenny an hour for every incandescent lamp. A breakdown in the lighting will be provide against by reserve machinery. After some discussion as to the fines, the proposal was adopted *nem. con.*, and Chelmsford will now have the distinction of being the first English town to be thoroughly and carefully lighted by a well considered system of combined arc and incandescent lamps in a manner electrical engineers can approve.

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TELEPHONE CONDUCTORS.

BY R. W. JAGGARD.

It is of great importance that the proper size of telephone wires should be ascertained, both from the commercial and from the scientific point of view. The two things to be considered are initial cost, and freedom from induction.

An experimental cable, laid on the Pennsylvania Railroad between the Broad-street and Thirty-second-street stations, in the spring of 1887, contains 53 conductors, 52 of them are number 16, and one is number 18, American gauge. The greater number of the conductors are used for telegraph purposes, and a part of the remainder for telephones.

About a year ago a phonoplex circuit, working between Philadelphia and Harrisburg, was introduced into the cable. The heavy inductive impulses used to operate this circuit caused considerable disturbance on the telephones. An attempt was made to ascertain which of the conductors was least disturbed by those inductive impulses, and it was found to be the 18-gauge conductor, the electrostatic capacity of which was about 0·11 microfarads per mile, while the 16-gauge conductors averaged about 0·14 microfarads measured on a cold night at a temperature of 12deg. Fahrenheit.

Substituting the 18-gauge conductor for one of the 16, we increase the resistance of the circuit, including the telephones, not quite 2 per cent.; but the electrostatic capacity is reduced over 20 per cent.

Two per cent. increase in the resistance of the circuit could not be felt in operating the telephones, but a decrease of 20 per cent. electrostatic capacity was clearly discernible in greatly lessening the inductive disturbances; and, on that account, the 18 gauge was selected for the most particular telephone circuit.

As a majority of telephone circuits diverging from the exchanges are less than a mile in length, it is evident that smaller-sized conductors with greater insulation should be used. Not that high insulation is desirable, but that the thicker the covering and the smaller surface of conductors is a principle that would be well to follow. This principle was proved conversely by using two 16-gauge conductors in place of a single conductor, which doubled the inductive disturbances, in the same proportion to the increase in electrostatic capacity; at the same time the resistance of the conductor was halved.

Carrying out the above principle, it is evident that small conductors are advantageous as long as the conductors are confined to cables within the area of cities; but when extending beyond city limits, they should be connected with wires of larger dimensions, especially so when metallic circuits are used, as in long-distance working. In cases of this kind conductors can be transposed and crossed on the poles to neutralise, or nearly so, all inductive disturbances.

There is another feature worthy of notice in laying up the conductors of a cable in order to reduce the electrostatic capacity. Cotton has exceedingly low electrostatic capacity, and, as in the case of the cable above mentioned, the conductors are all twisted tightly in the same direction like the strands of a rope, allowing the cable to absorb a minimum amount of the resin mixture, which has a much greater electrostatic capacity than cotton. By this means the electrostatic capacity of the conductors is very low.

It is very plain, therefore, that even for metallic circuit purposes there are no advantages to be gained by having the conductors twisted in pairs, as the cable then becomes more bulky, and fewer wires can be put in the same diameter of pipe. There is also a greater space within the cable itself to be filled up by the resin mixture, thereby increasing the electrostatic capacity.

In Brooklyn a No. 19 American gauge-conductor, having three windings, laid up in pairs, is reported as having a capacity of about 0·19 microfarads per mile, while this cable with a No. 16 conductor and two windings shows but 0·14 microfarads at the temperature mentioned.

The New York and New Jersey Telephone Company sent an electrician to Brooklyn to measure the electrostatic capacity of these conductors. That company is able to furnish comparative results.

Vice-President Thomson, of the Pennsylvania Railroad, uses two of these conductors in connection with the long-distance telephone lines to New York, and the service is said to be quite satisfactory.

It should be borne in mind that the electrostatic capacity of the metallic circuit is but one-fourth of the sum of the two sides when the capacity is taken as two separate conductors. Using the second wire in place of the ground for the other pole of the battery, with both conductors open at the distant end.

Similarly, the insulation resistance is double that of the sum of the resistance taken in the usual manner. For example: if one conductor should measure ten and the other five megohms per mile, when insulation is taken in the usual manner with one pole of the battery to earth. If the other pole of the battery is then connected to the second conductor, the lines of insulation resistance on one side, 10 megohms to earth and out of earth to the other conductor, five megohms, which makes the insulation of the metallic circuit 15 megohms per mile.

The foregoing hints are more especially intended for those who are about to open new telephone exchanges with underground or cable conductors in any form, and should receive the careful consideration of telephone managers, who, as a rule, are more commonly selected for business qualifications than electrical knowledge.

Electricians, as a general rule, are not good business men, and managers generally copy after some other managers, but "if the blind lead the blind they both fall into the ditch," which is the scriptural name for conduit.

The use of large size conductors in short-distance telephone working reminds me of the lack of scientific knowledge when the first Morse telegraph was put into operation. They had an idea that the same size conductor should be used in making the relay that was used for building a line, and thereby employed a No. 14 copper wire to wind upon the iron core. Sixty cells of Grove's battery were required to operate a line 40 miles long, and the magnetic effect was so weak that it required the most delicate adjustment to enable the armature to be moved. With that sized wire but few convolutions were brought into proximity to the iron core. This difficulty was overcome by using a wire of smaller dimensions.

It can be readily seen, therefore, that large-sized conductors are not always advantageous.

WHY SOME INVENTIONS DO NOT PAY.

BY S. F. WALKER.

One reason is that some inventors never complete their work. And there are two offenders of this kind. One set of men, as your correspondent, Mr. Bernhard Dukes, very properly pointed out, persist in inventing things they know nothing whatever about, and are therefore constantly posed by some trifling difficulty that anyone who understands the subject could have helped them out of in two minutes. They will not seek help from those who do understand the matter for fear the latter should steal the idea.

An instance that came under my own cognisance will perhaps illustrate what I mean.

A friend of mine, a very able man, who had worked out several very remarkable inventions in connection with electricity, was working at one in which the armature of a powerful electromagnet was required to detach itself from its poles very quickly. He could not persuade the armature to let go without a touch of the hand, which, of course, it would not get in actual work. I believe he had been working round this difficulty for some weeks, when I happened to call, and he confided his trouble to me. He had previously been asking me, by letter, what iron we used for electromagnets and so on, but my replies had brought him no relief. On seeing the apparatus at work, the cause of the trouble was visible at once. He closed his magnetic circuit each time that his armature came up to the poles, the naked iron of the armature bearing on the naked iron of the poles, with the usual result. As your readers all know, the insertion of a slip of paper between the armature and the poles, thereby breaking the magnetic circuit, overcame the difficulty, and I heard no more of that trouble. In many cases, however, inventors who are not masters of the subject they are

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working on get over their difficulties by adding to the apparatus. It often happens that the addition introduces a fresh difficulty quite unforeseen, and this is overcome by a further addition and so on, until the apparatus, when it finally leaves the inventors' hands, is too complicated for any ordinary human being to understand, much less to buy.

Max Adeler's clever sketch of the inventor of the carbolic mat, who had met with such a series of difficulties, is by no means so much of an exaggeration as it might seem.

The carbolic mat was to prevent the communication of disease, only its odour was unbearable, therefore a nosebag containing a special preparation was added.

The special preparation, however, evaporated, therefore two bottles of the preparation were given. These, however, if carried in the coat-tail pocket and subjected to the concussion of falling down backwards, were liable to explode, therefore a life policy in the inventors' own company was given to all buyers of the carbolic mat at special rates.

The other class of inventors who never finish are those who are always improving, but never completing for the market. No sooner does one of these men bring his idea up to a certain stage, than right in front of him appears a better one. Perhaps it is a cheaper method of construction, perhaps a better method of working. In either case the original plan is dropped forthwith, and a fresh start made on the improvement, that being abandoned in its turn for a further improvement, and so on.

An accountant related to me an experience of this kind some time since. An inventor had produced a very clever machine for making brushes. A company was formed, plenty of working capital put in, and everybody was enthusiastic; and yet that company never paid a dividend, and finally liquidated, because they were always seeking to improve the machine, and orders had to wait till the improvements were complete. As originally arranged, my informant assured me, the company should have done very well indeed. It was not heavily loaded with dead capital or promotion money, and its working expenses were small; while the cost of production by the original machine left a margin for a splendid profit, and orders were plentiful. Yet the company was wrecked because no sooner was the plant down than the inventor saw his way to reducing the cost still further by another machine, and he so dazzled the eyes of his directors, who presumably were not business men, that they actually joined with him in holding the business back, losing present profits in order to secure the additional profit that would come when the new machine was made, and this process, I believe, was repeated till the company wound up.

SINGLE-STROKE MAGNETO BELL.

Mr. A. A. Campbell-Swinton has made a speciality of magneto-electric bells, constructed exactly as a dynamo and motor. A small fully-formed magneto-dynamo machine is used for the transmitter, and a small motor in the bell

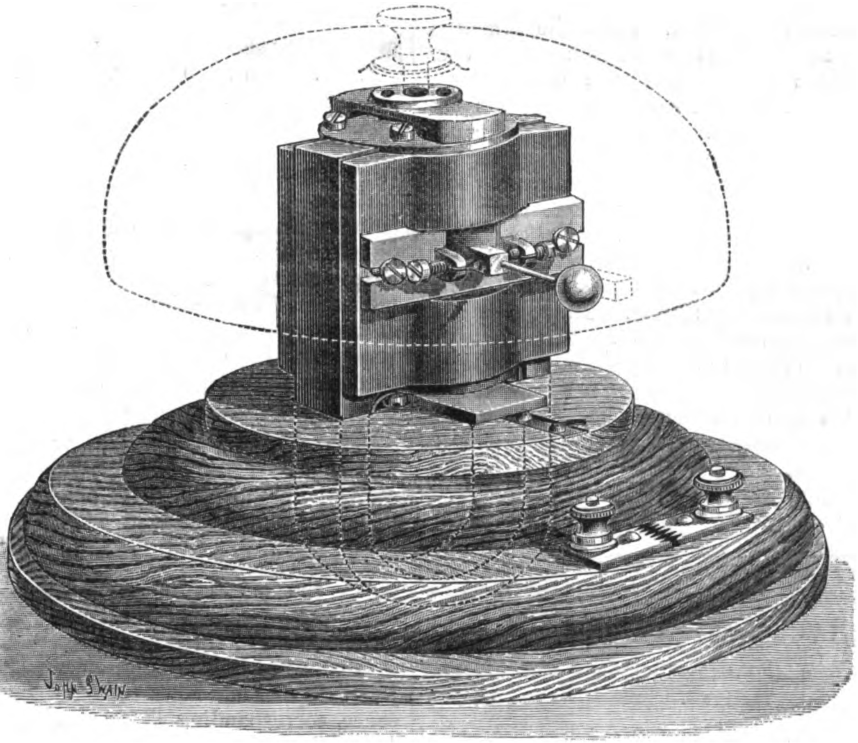

Fig. 1.—Cox-Walker Swinton Single-Stroke Magneto Electric Bell.

itself. We illustrate herewith the latest form of single-stroke bell, which is very compact and well-arranged in its details, and admirably adapted for use for railway or col-

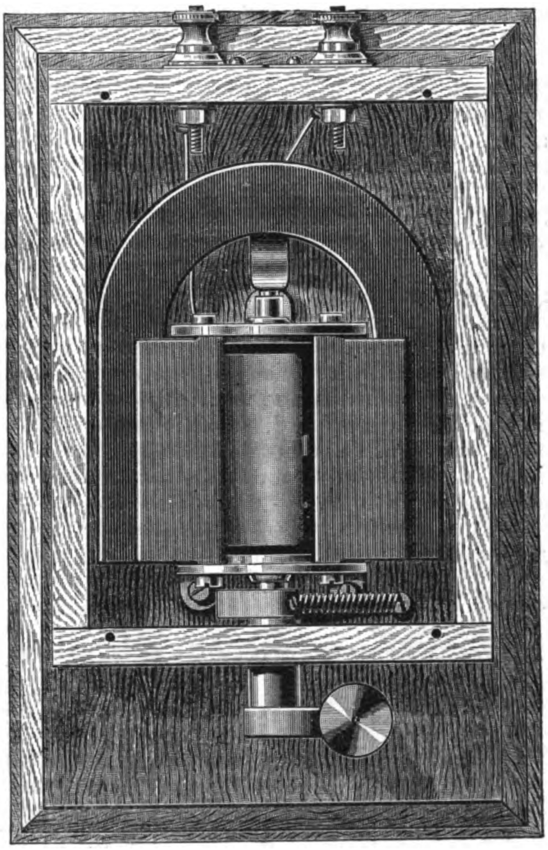

Fig. 2.—Transmitter for Magneto Bell.

liery signalling, or other use where extreme simplicity and the absence of batteries is desirable.

In these bells a strong compound magnet is fixed firmly in a suitable position, and a small Siemens-wound H arma-

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ture, suitably wound for the purpose required, is centred between the poles. This arrangement is the same for both generator and receiver, the position of the magnets only being different. The armature of the generator has a lever and finger-knob attached to it by which the armature can be rapidly jerked by pressure of the finger; strong spring rings it back to position.

The bell itself is shown in Fig. 1. Here the armature acts as a motor, with a strong jerk, when an instantaneous current is sent. The armature has a small hammer attached, which strikes against a projection cast on the inner surface of the dome or bell. Fig. 2 shows the transmitter. One stroke on the knob makes one ring on the bell, which may thus be used for signalling purposes. The bell will ring through any ordinary line resistance, ringing through up to 1,000 ohms as now wound.

These magneto single-stroke bells have been adopted upon the Cambrian Railway, where they were tested for some time with very satisfactory results. They have also been introduced with great success at several collieries in the North of England. There is very little doubt that these bells will be introduced for many ordinary purposes as well as for signalling, as the entire absence of batteries and the attendant trouble is an immense point in their favour. The bells can be seen working in action, and suitable for various purposes, at Mr. Campbell-Swinton's offices, 66, Victoria-street, Westminster.

THE EFFICIENCY OF METHODS OF ARTIFICIAL ILLUMINATION.*

BY EDWARD L. NICHOLS, PROF. OF PHYSICS IN CORNELL UNIVERSITY.

(Continued from page 316.)

The second method pursued by Mr. Merritt was intended rather as a check upon the results already obtained than in the expectation of gaining further data. The rays of the lamp were allowed to fall upon the face of a delicate thermopile placed at a distance of about 60c.m. The thermopile was in circuit with a low-resistance galvanometer of the well-known "tripod pattern" of Sir William Thomson. The deflection of the galvanometer was taken as a measure of the total radiation, luminous and non-luminous, which fell upon the face of the pile. A cell containing a solution of alum was now interposed, and the reduction in the galvanometer noted. The arrangement of this apparatus is shown in Fig. 2.

An aqueous solution of alum fulfils much more nearly the desired condition of complete opacity to "dark heat" and complete transparency to the rays of the visible spectrum than any other substance, but a certain small percentage of the longer wave-length will pass through such a bath, and a considerably larger percentage of light giving rays will be cut off by it. The proper corrections are, however, easily determinable, and when, in this case, they had been determined and applied, the ratio of total to luminous radiation was found to be in gratifying agreement with the efficiency obtained by the calorimetric method already described. *See* Table II.

TABLE II.

Lamp B.—An Edison 16-c.p. Lamp. Resistance = 249 ohms.

E.M.F.	W.	C.P.	L	$\frac{L}{W}$	$\frac{L}{C.P.}$
63·0	25·4	0·3	0·42	0·016	1·61
74·6	37·8	1·0	0·77	·021	0·79
85·4	52·5	2·5	1·96	·037	0·78
99·0	72·2	6·3	4·30	·059	0·68
116·0	102·0	15·2	7·38	·072	0·49

Lamp C.—Weston 16 c.p. Cold resistance = 402 ohms.

E.M.F.	W.	C.P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
72·0	21·6	0·4	0·46	0·021	1·27
87·4	33·5	1·5	1·10	·033	0·76
102·0	47·8	4·4	2·09	·044	0·48
117·0	66·1	10·7	3·19	·048	0·30

Lamp D.—Weston 16 c.p., 70 volt. Resistance = 152 ohms.

E.M.F.	W.	C.P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
43·0	25·8	0·5	0·53	0·021	1·06
50·7	36·0	1·6	0·97	·027	0·62
60·5	52·0	5·2	2·03	·039	0·39
67·5	65·5	11·0	3·95	·060	0·36

Lamp E.—Bernstein 8 c.p. Resistance = 11·3 ohms.

E.M.F.	W.	C.P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
12·2	25·2	0·2	0·20	0·008	1·00
13·4	30·8	0·5	0·41	·013	0·84
15·0	40·4	1·3	0·75	·018	0·57
16·4	53·2	4·1	2·03	·038	0·50

It is interesting to compare these results with some obtained by still another method. Captain Abney and Colonel Festing, in the *Proceedings* of the Royal Society, have described a series of elaborate studies of the radiation of the incandescent lamp. The portion of their very important investigation which has a bearing upon the efficiency deals with the exploration of the spectrum of the lamp, under various degrees of incandescence, by means of an exceedingly sensitive thermopile. The energy of the visible spectrum of most sources of light is so minute that it has generally been deemed impracticable to measure it in this way. Captain Abney and his co-worker have, nevertheless, secured measurements covering not only the extensive regions of the so-called heat spectrum lying inside the red, but also the shorter wave-lengths which constitute the visible spectrum. Their results are shown graphically in Fig. 3.

One of the British Electric Company's lamps was subjected to measurement in six different states of incandescence, corresponding to 33·6, 60·2, 93·8, 116·4, 130·8, and 150·5 watts respectively. The curves show the intensity of each wave-length of the spectrum when the above amounts of energy were expended in the filament, and the total area enclosed by each curve affords a relative measure of the total radiation of the lamps in the state of incandescence in question. I have added to this diagram, of which, in other respects, Fig. 3 is a faithful reproduction, the vertical line lying between scale divisions 5 and 6 of their scale. This line marks the boundary between the visible and invisible spectrum. The entire area to the right of that line represents the energy wasted in the lamp; the much smaller area to the left comprises the light-giving rays. The ratio of the entire area of each curve to that portion lying within the boundaries of the visible spectrum gives us the efficiency of the lamp for the state of incandescence of the expenditure of the number of watts for which the curve is drawn. This ratio increases from a very small value with the brightness of the lamp.

I have made approximate integrations of the areas embraced by the curves for 150·5 and 130·8 watts, respectively, for the purpose of comparing the efficiency thus calculated with the results obtained by Mr. Merritt. The ratios are:

Watts.	Efficiency.
150·5	5·55 per cent.
130·8	5·15 „

The corresponding values for lower states of incandescence are all smaller than the above.

It will be seen that these results are in complete agreement with those obtained with the glass calorimeter and by the method of Melloni. We have, indeed, reason to feel that our knowledge of the efficiency of the incandescent lamp, in so far as it can be expressed by the ratio of luminous to total radiation, is well grounded, and that we are in position to determine the light-giving efficiency of any type of glowlamp in any condition of incandescence with the same certainty and exactness which is attainable in the measurement of other machines for the transformation of energy.

The average net efficiency of the incandescent lamps of to-day, for we may have untouched for the present the efficiency of the process by which the latent energy of fuel from which the current is generated has been converted into electrical energy, is rather below than above 5 per cent., and since the ratio of total radiation to light-giving radiation increases but slowly as the temperature of the radia-

* A paper read before the American Institute of Electrical Engineers, March 12, 1889.

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ting body rises, the efficiency is not likely to be increased in any very marked degree until we shall have learned how to suppress altogether these long wave-lengths which yield us dark heat, and are able to limit the vibrations of our source of light to that brief octave which comprises the wave-lengths, to which alone the human retina responds.

Whether this great step is to be made by robbing the glow-worm and firefly of their secret, as has been suggested in a recent address by the director of the Sibley College of Mechanical Engineering,* or by development along the lines sketched the other evening by Prof. Brackett at the meeting of the Electric Club, or by the application of some principle as yet unconceived, we know not. Meantime, we have in the methods of artificial lighting of to-day abundant material for study and investigation.

The investigation of the efficiency of the arc light, by the methods under consideration, is a much more difficult matter than the same determination in the case of the incandescent lamp. The radiating surface of the latter is very nearly of the same temperature throughout, and the ratio of total radiation to luminous radiation, obtained for the bundle of rays sent out in a single direction, gives us at once the measure of the efficiency. In the arc we have, however, a light-giving area of great brilliancy in the immediate neighbourhood of the arc, and the temperature of the carbon falls with great rapidity from the maximum at the point and crater to regions which are at a red heat.

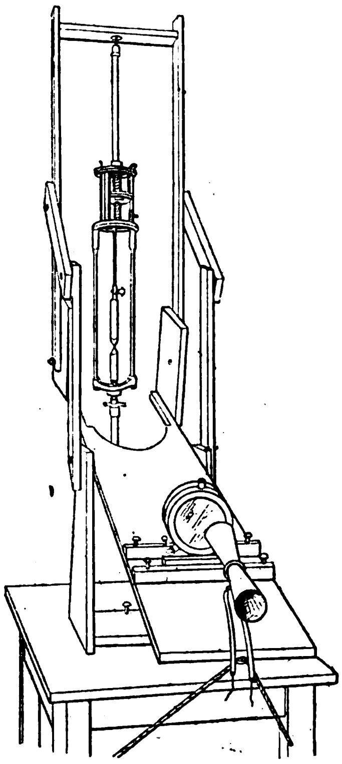

FIG. 4.

The entire light-giving area is included between the line surrounding the positive carbon, which is at red heat, and the corresponding line upon the negative carbon. Between these two lines we pass rapidly through regions the light from which varies with the degree of incandescence by insensible gradations from that which a red-hot surface is capable of emitting, to that coming from carbon at the highest temperature which that substance can be made to assume. Now, the curve of distribution of c.p. taken in a vertical plane is, as we all know, a very peculiar one, and if we place our thermopile with alum cell interposed to measure the energy of the light-giving rays, the amount of radiation received upon the face of the pile will greatly depend upon the position in which the apparatus is set up. At an angle of 45deg. or 50deg. below the horizontal plane, for instance, the amount indicated will be five or six times greater than in the horizontal plane. Now, the surface of total radiation is much larger than that from which the light-giving rays emanate. It includes, in addition to the incandescent surfaces near the arc, all those portions of the carbons which are heated by conduction or by the current.

The amount of heat radiated from regions which are below the red heat is very considerable, and forms an important factor in the determination of the efficiency. Were the distribution of total radiation in the vertical plane identical with that of the light-giving rays, the measurement of their ratio with the axis of the thermopile in any plane which passes through the arc would give us the efficiency of the lamp; but the curve of distribution of total radiation is not the same as that of candle-power, and the ratio in question is a function of the plane which the axis of the pile makes with the horizon. It becomes necessary, therefore, to make an exploration of the entire zone through which the lamp sends out rays, determining the ratio of total to luminous radiation for each angle, and then to integrate the results. Such an investigation is now in progress under my direction, and H. Nakano, who is carrying on the experiments, has reached some exceedingly interesting results. The research will soon be ready for publication in its complete form, and it will afford us much more definite data concerning the radiations of the electric arc than we now possess. It will not be out of place even now to say a word concerning the method which is being employed and the general character of the results already obtained.

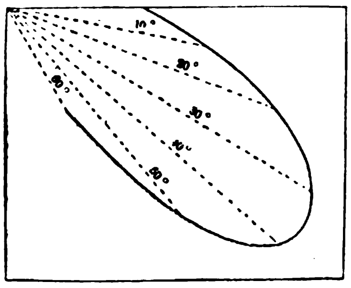

FIG. 5.

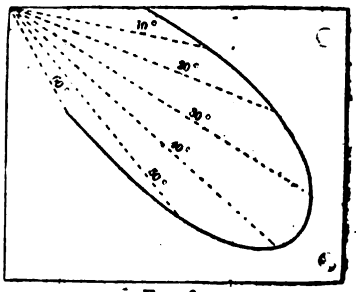

FIG. 6.

The first measurements were made by the second method employed by Mr. Merritt, the thermopile in the horizontal plane. The lamp subjected to measurement was of the long arc type, with 9 amperes of current and 45 volts. The efficiency in this plane was found to be surprisingly small. It was found, moreover, to vary in marked degree with the diameter of the carbons used, increasing as the diameter decreased to the point at which the carbons were rendered hot by the current, when, as might be expected, it fell off again.

The lamp was then mounted in a frame which also carried the thermopile and alum bath, and which was so constructed that measurements could be made at any desired angle. All necessary changes of angle could be made without varying the distance from the arc to the face of the pile, or the relation of the alum bath to the latter. By means of this apparatus, which is shown in Fig. 4, it has been found possible to determine the ratio of total to luminous radiation throughout the zone of radiation of the lamp, and to plot the curve of distribution of each.

Without entering into the details of an incompleted research, I may indicate the general character of the results by means of a diagram. The curves shown in Figs. 5 and 6 are those relating to a "long arc" lamp, with carbons ·45in. in diameter. They represent respectively the distribution of luminous and total radiation emanating from the lamp. The radii show the positions for which measurements were taken; distances measured along these lines from the origin to each curve give the relative intensities of light-giving and total heat energy in each position.

(To be continued.)

* "The second of these greatest of inventors is he who will teach us the source of the beautiful soft-beaming light of the firefly and glow-worm, and will show us how to produce this singular illuminant, and to apply it with success practically and commercially. This wonderful light, free from heat and from consequent loss of energy, is nature's substitute for the crude and extravagantly wasteful lights of which we have, through so many years, been foolishly boasting. The dynamo-electrical engineer has nearly solved this problem. Let us hope that it may be soon fully solved, and by one of those among our own colleagues who are now so earnestly working in this field, and that we may all live to see him steal the glow-worm's light, and to see the approaching days of Vril predicted so long ago by Lord Lytton."—ROBERT H. THURSTON (*Transactions of the American Society of Mechanical Engineers, 1881, p. 22*).

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THE

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

DONNER UND BLITZEN.

Those who attended the last meeting of the Institution expected a grand display of fireworks—verbal and actual—and were not disappointed. When Prof. Lodge enters upon the warpath some hard knocks are sure to be given, for he has the eminent quality of going straight at his object. Circumlocution is outside his idiosyncrasies altogether. He gets his nail into the wood, and drives it home with a sledgehammer—no puny or flimsy made-to-be-sold hammers for him. Usually, the sledgehammer comes down fair and square, leaving no possibility of uncertainty as to its action, but occasionally it does miss its object, or make a slanting stroke. One such example we might cite in a recent controversy on "fans." Another will be found, it may be, in the dogmatic assertions in the paper read before the Institution. Prof. Lodge is one of the ablest of the younger generation of professors, and has managed to cast aside many of the prejudices and failings of mere bookmen, but when he, in his own mind, sees a thing clearly, he is prone to assert that "it is so," "it cannot be otherwise," or in the words of the paper, "nor do I believe they are at all attackable from the side of theory." Just as Prof. Lodge speaks to the point, so we are inclined to do, and to say that this belief is not in accordance with a true scientific desire to arrive at the whole truth. Prof. Lodge, in fact, limits his theorists to a dozen men or so whose theories coincide with his own, and does not include among theorists those whose opinions he and those who agree with him term heterodoxical. It is this passion for dogmatic assertion that we wish to combat. The history of scientific progress shows the weakness to have existed in all ages of scientific investigation, and yet every generation has seen new theories taking the place of the old. If Prof. Lodge retorts that his reference is solely to facts, then we say theory has nothing to do with the matter. A fact is a fact all the world over, and does not want nor can it be controverted by theory. He tells us that a discharge by means of a pre-arranged path, "a steady strain," and one by means of "an impulsive rush," act differently, and he appeals to experimental proof to confirm his statement. No one disputes the facts arising from his experiments. There they are for all to see and to obtain at will. This is altogether a different question from possibility of being attacked by theory. Prof. Lodge practically says that from the time of Franklin to that of Faraday, and till his lectures at the Society of Arts last year, only one phase of the question had been considered. He points out another phase, and having discussed it, and made certain conclusions, claims finality. How does he know that an unborn Prof. Lodge may not in twenty-five years add another phase

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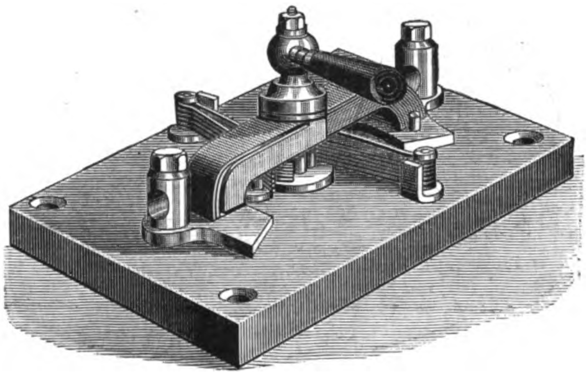
overlooked and unconsidered by the present holder of the title? If we misinterpret the position, we are sorry, but that an effort has been made to support the conclusions stated without always considering that the same "extracts" may bear two interpretations is plain. An example is cited from a writer in *Nature*, who is mildly reproved as giving "contradictory advice." Another reader than Prof. Lodge *may* be unable to see the contradictions. Fish were killed in a fishpond, from the effects of lightning—a rod having its end in the pond. The writer of the note asks, "When will people learn to make proper earth connections?" Prof. Lodge says, "Before an accident, the pond would be pointed out as an excellent earth, *as indeed it most likely was*." The italics are ours. We, in our ignorance, thought the common teaching to be that there are ponds and ponds, or water and water. Does not Anderson in his book, now some years old, point out that a rod led to earth in a pool of water in a rock probably does not make a good earth, and just so an artificial pond or a natural pond of certain character has long been held to be bad earth. Suppose the pond of the writer in *Nature* to have been an artificial pond, well concreted and cemented, it would not be good earth, and no accepted authority would so advise. Prof. Lodge does not seem to know the nature of this particular pond, neither do we, and the matter is referred to only to show that there may be no contradiction in the advice from "advisers *re* earth for rods" when the whole facts are known.

Having had our say as to the inadvisability of dogmatising over theories, and the weakness in attempting to find facts to suit theories, we must join heartily in thanking Prof. Lodge for his great services in calling attention to the present state of electrical knowledge as regards protection from lightning. He has pointed out dangers hitherto ignored; he has, without mercy it may be, attempted to wake those in authority to a due sense of their responsibility. He has shown sufficient reasons for the report of the L. R. C. to be immediately withdrawn, for the conference to be reconstituted, and for another report to be issued, with suggestions, after taking into consideration the new light thrown upon the subject. Prof. Lodge gives the basis of the work of such a conference in the summary of statements at the end of his paper. No doubt the discussion upon the paper will throw further light upon the question, and our suggestion of a new committee find favour with those interested in the matter. It is quite certain that agreement will not be obtained at these public meetings, but the advisers of the Government will be bound to pay attention to the tendency of modern scientific thought, though without further and more definite assistance they will be unable to decide as to what is best. Architects who have the designing of private mansions, and have to arrange for protection, will soon be in doubt as to what to do, how to do it, or how to go to work. On the one side, they know about copper, while on the other, they are told "iron" is better. We only see a way out of the difficulty by means of a conference and an authoritative report. Will the Institution take action?

MAIN SWITCH.

The evolution of the main switch is proceeding towards perfection, and the latest development, embodying the fulfilment of the most recent requirements, is furnished by Messrs. Woodhouse and Rawson in the main switch we illustrate.



Woodhouse and Rawson Sudden-Break Main Switch.

The appearance of the switch, which is a large one, is well shown, as well as the various improvements therein. To briefly describe it: the base is of slate; the handle is loose on the cross bar, which it turns with a pin, ensuring quick break; there is a small "buffer spring" at each side to break the force of the break; the spring is a strong steel one of several wires, to make the break strong; the cross piece is very massive, and is constructed in numerous plates, ensuring good contact. The switch is provided with large contact screws for large cables, and is specially suitable for central stations, or large main wires where heavy currents have to be carried. The switch is well designed and well made, and should command an extensive sale.

ON LIGHTNING, LIGHTNING CONDUCTORS, AND LIGHTNING PROTECTORS.*

BY DR. OLIVER LODGE, F.R.S., MEMBER.

Introduction.

About this time last year I delivered two lectures to the Society of Arts on the subject of "Lightning Conductors," in pursuance of a bequest made to the society in memory of the late Dr. Mann. In those lectures I abstained, as far as possible, from practical recipes, and from anything like authoritative advice, contenting myself with calling attention to certain aspects of the subject which had been overlooked. I ventured to imply that none of the older electricians had any notion of the real conditions of the problem; that they all, from Franklin to Faraday, and down to the present day, treated it as a much easier matter than, in fact, it is; and that there had been very little real progress in this particular department since the time of Franklin.

Recent advances in electrical theory made it easy for me to see further into the matter than the far greater men of the past had had any chance of doing; and a few very simple and easy experiments soon brought the conditions of the problem clearly before me.

It was these conditions upon which I laid emphasis in my lectures to the Society of Arts. Any practical outcome I left to a later period, and very likely to other hands. The first requisite seem to be to grasp the conditions of the problem as illuminated by theory; the second, to carry out practical reform in the light of a large experience.

* Paper read before the Institution of Electrical Engineers.

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Such few practical recipes as I did surreptitiously introduce I fully expected to hear criticised, nor did I lay any stress on them at the time. (I may say, however, that I have seen no occasion since to importantly modify any of them, and that my position in respect of these practical hints is stronger now than it was then, inasmuch as I find that the large experience of the Belgian electricians, who have given more attention to this subject than perhaps any other school, has led them to recommend in recent years almost precisely the same methods of protection as those I advocated : their views being acquired almost entirely by practical experience and scarcely at all by theory.)

The theoretical and experimental portions of my lectures were, however, matter of serious consideration with me, and nothing was set down under these heads but that of which I was absolutely sure. These portions have by all pure physicists been, so far as I know, universally accepted ; as, indeed, they contain nothing but what anyone of them could have easily arrived at had he happened to give sufficient thought and attention to the subject. They have not been attacked, nor do I believe they are at all attackable from the side of theory.

But from the side of experience an attack has come, and, strange to say, it has been directed, not at the few practical suggestions, which might be expected to be vulnerable on that side, but at the theoretical and purely scientific portions.

At the Bath meeting of the British Association, the then President of Section G, speaking in the light of a most gigantic experience—a personal acquaintance with over half a million conductors—led a most good-humoured attack against the doctrine of my lectures, and, exercising his well-known rhetorical and oratorical powers, succeeded probably in impressing the general bulk of the audience with the belief that he had, on the whole, the best of the battle; though, at the same time, I expect they were in a state of utter bewilderment as to what the conflict had been all about, and where the difference " 'twixt tweedledum and tweedledee " precisely lay. The battle was, however, admittedly a drawn one, and at its close Mr. Preece magnanimously offered me another field, with an audience of an altogether different calibre to the general public of Bath, by getting your secretary to invite me to read a paper before this Institution. Thus much by way of historical note and introduction. Now for the scientific portion of the paper.

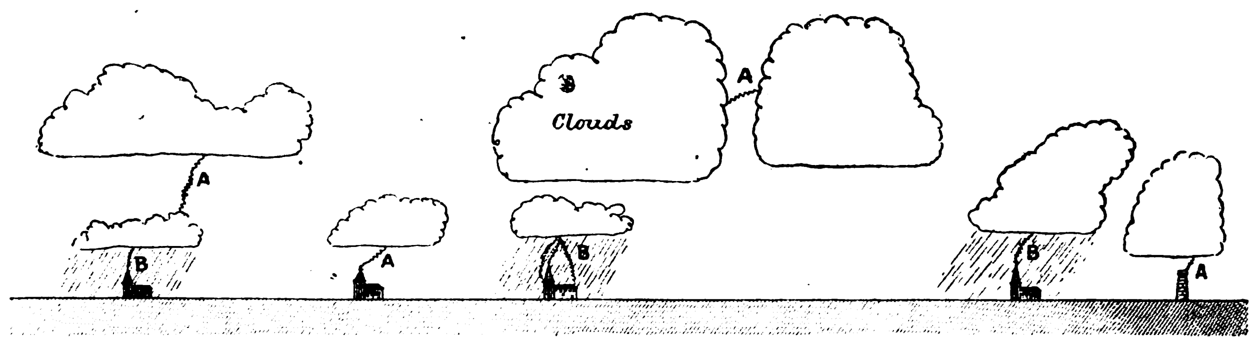
I begin by running over some of the conclusions at which I arrived, and proceed to re-establish and demonstrate their correctness either by theory or by fresh experiment, whichever may seem the most simple and satisfactory under the special circumstances.

Two Main Cases of Lightning Flash.

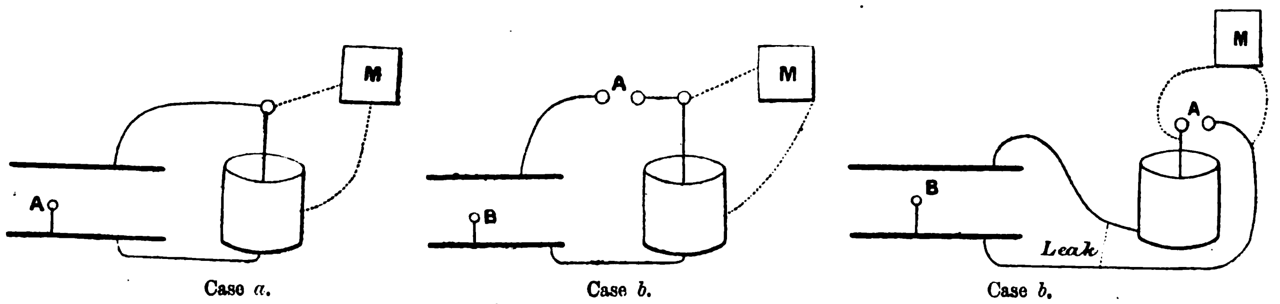
1. All discharge is virtually that of a Leyden jar. There are always two conductors separated by dielectric, and the discharge is a breaking down of the dielectric at its thinnest or weakest place. In a thunderstorm the charged conductors are obvious, being either two clouds, or else a cloud and earth, and the dielectric is the air between.

2. It must sometimes happen, when one cloud discharges into another, that the potential of this other is suddenly raised high enough to cause it to discharge into the earth, even though no strain previously existed in the air between it and earth. The same thing may happen in various other ways when two clouds spark into each other, as indicated by the diagrams (Fig. 1).

3. There are, therefore, two main cases—(*a*) when the strain in the dieletric near the earth has been of gradual growth, in which case the path of discharge will be prepared inductively beforehand; (*b*) when the strain arises so suddenly that there is no time for any pre-arranged path. The first I call "steady strain"; the second, "impulsive rush." It is most important to recognise these two cases, and to understand the extremely different conditions attending the two. The first case only was ever contemplated by the older electricians ; in fact, so far as I know, it was my experiments last year which first called attention to the other case.



Case *a*. Case *b*. Case *b*.



Case *a*. Case *b*. Case *b*.

FIGS. 1 AND 2.

Figs. 1 and 2 represent the same conditions as they may occur in nature, and as they can be arranged artificially. Case *a* in each figure is the steady-strain case. The others are varieties of the impulsive rush, when a spark at A precipitates a spark at BD ; the place where B occurs having been subjected to no preliminary strain. Clouds compared to coatings of jars ; spaces between them compared to glass or other insulating space. The position of the charging machine, M, is indicated in Fig. 1 for convenience. The leak or imperfect conductor in the second case *b* of Fig. 1 is needful in order that the jar may charge. It takes no part in the discharge. Its place is taken in Fig. 2 by the rain-shower. In case *b* the rain-shower or leak are permissable, but unnecessary.

Conditions of Protection and of being Struck, under the Circumstances of each Case.

4. I will now illustrate experimentally* the conditions under which discharge occurs in each of these two main cases ; and I will take first the case of steady strain, or case *a*. This insulated sheet of tin plate is supported horizontally a foot or two above another plate lying on the table, and it is electrified by a Wimshurst machine. It represents a charged cloud hovering over the land, the lower plate representing the earth. Between the two I can erect buildings, and lightning-conductors terminated in various ways. The typical terminals which I will here use to illustrate the conditions are four—viz., a large knob, or, as I shall call it, a "dome"; a small knob, which I shall call "knob"; a sharp point ; and a gas flame, to represent a chimney, or other furnace current of rarefied air. Putting the knob and the dome between the plates, we find the knob struck by preference, even though the dome stands at a much higher elevation. Introducing the point, we find it protects both, by a silent discharge, until it is lowered very considerably ; and that then several points may protect when one does not. Replacing the point by the flame, we find that it protects too, but not so efficiently as the point, and that it gets curiously beaten down and darkened in the act of protection. The point is not struck by a noisy flash until it is raised pretty close to the upper plate when it is struck ; but a

* The experiment was shown with a splendid machine most kindly brought over and erected for the purpose by Mr. Wimshurst himself, whom I cordially thank.

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bunch of points is even then not easily struck, sometimes continuing to discharge with a constant fizz right up almost into the cloud.

5. Try the effect of a bad earth or other very high resistance interposed in the path of the conductor—say a capillary water tube or a bit of wet rag or a wet string. The violence of the spark is greatly lessened, and the sound is now gentle, but that which was struck before is still struck; resistance, so long as it be something short of infinite, makes no difference to the ease with which a given object is struck under the circumstances of this case 1. Insert the wet rag in path terminated by point, and it still protects, practically, as well as before. Insert it in path terminated by knob, and it gets struck at the same elevation as before. The fact is that the path of the disruptive discharge is all negotiated and prearranged in the air above, especially on the surface of any small conductor reared into this space, and the resistance which the flash may ultimately have to meet with in its passage to earth is a thing of subsequent consideration.

6. So much for the conditions attending case *a*, the steady strain. Now attend to case *b*, the impulsive rush. We shall find everything very different. Alter the connection so that a charged Leyden jar must, when it discharges, discharge direct into the upper insulated tin plate, and thence overflow to the ground if it is able to raise the potential high enough. If the plate is too far above ground for a flash to occur, the Leyden jar does not completely discharge; it only produces a number of fizzes and spits, and the greater part of its charge remains in it. But when the upper plate is within sparking distance of the ground (and the sparking distance under these circumstances is surprisingly great by reason of the impetus with which the electricity rushes into the top plate), then the jar discharges completely, and we have a violent crack both between the knobs of its discharger and in the air gap between the two plates, which is in the path of the discharge; the arrangement being really two condensers in series, but only one charge. The only object of the Leyden jar in case *a* is to give more body to the flash. In case *b* the Leyden jar, or its equivalent capacity, is essential.

7. Putting the dome and the knob between the plates arranged as in case *b*, we find that one gets struck as easily as the other; the knob has now no advantage—whichever is the higher, that gets struck, without reference to other considerations. Introducing the point also, we find precisely the same is true for it; its protective virtue, so much insisted on by the older electricians (among whom I suppose I am right in reckoning my chief antagonist), is entirely non-existent. It gets struck no more easily, and no less easily, than the dome, and it gets struck by a flash of precisely the same noisy character as the others get struck with. A bunch of points acts in exactly the same way. A comb of 24 needle-points protects nothing, and gets struck just the same as anything else.

8. Now introduce the flame, and one notices a marked difference. In case *a* it protected less well than the point, but it was not struck noisily any more than the point was. In the present case it gets struck with violence, and it gets struck much more easily than anything else. Adjust dome and knob and point at about the same level, and they get struck, one or other, at random. Adjust the flame a great deal lower, and it protects them all, not by silent discharge, but by getting struck itself instead. "Protection," however, is in this case not the word to use. The flame better represents a chimney requiring protection, while the point corresponds to the pointed terminal of a lightning-conductor raised a good deal higher with the intention of protecting it. Protect it, it does not, however; the flash strikes down the column of hot air and through the flame, while it avoids the more lofty pointed terminal altogether. Bring a point or a knob or anything into the column of hot air above the flame: then it gets struck easily enough, and protects the flame, but not if it is on one side of the hot-air column. The experiment has an obvious moral in relation to the protection of chimneys. It suggests that the continental plan of a bar or arch across the mouth of the chimney may, after all, be justified.

9. Try the effect of resistance in the path of the discharger *now*, and we find it is altogether different to what it was in case *a*. In case *b* things get struck according to their height, independent of the shape of their terminals, but not independent of their resistances. Interpose a wet rag in the path of any one, and that one fails to be struck; it is not struck, and it fails to protect the others from being struck, even though it be reared up till it touches the top plate. The top plate need not, therefore, be insulated at all carefully for this case *b* experiment.

Imitation of Lightning.

10. Now let us modify case *b* by making the top plate a sieve full of water, so as to get the flashes in a shower of rain. One cannot well try case 1 in a rain shower; the plate would be discharged too rapidly and continuously by the water-drops for its potential to fully rise. But in case 2 the top plate is not necessarily charged at all until the rush comes, and so the rain shower does no harm. Flashes in the rain can be got of surprising length and shape, for they make use of the water-drops as stepping-stones. By adding salt to the water they become longer still, but there is no need thus to improve its conductivity for what I want to show. Notice how the flash contorts itself, taking sometimes extraordinary paths as it jumps from drop to drop, but yet exhibiting its instantaneous character by showing the drops as stationary in its illumination.

11. Remove the things standing on earth-plate just beyond fair striking distance, and what do we see? Appearances precisely like those which are observed in many lightning photographs. A crowd of violet discharges fill the rainy air—forks and branch and multiple flashes, not very bright or very noisy, but extraordinarily numerous, and striking on innumerable places at once. A rot is set up in this air at every attempt of the jar to discharge, exactly as happens in one of the most striking of the photographs belonging to the Royal Meteorological Society. Masts and spars and deck and ocean may be simultaneously struck by these interesting flashes; and, though they do not here appear very violent, yet I expect that on the larger scale of Nature they are not very safe, and may easily have a heating effect sufficient to ignite bodies. These experimental ones are able to ignite gas in the midst of the rain.

12. While we have this arrangement at work we may as well try an interesting little experiment on what happens when lightning reaches water. The rain-water has here been collected in a zinc tray some 3in. deep, and by bringing a knob from the top plate, some 6in. or so above the water, a flash strikes it. It prefers to strike anything metallic if it can, but if there is nothing else within reach, it will strike the water. On reaching the water the flash forks out and ramifies in all directions in a crow-foot pattern, giving the same sort of appearance, only coarser, as that obtained by Mr. J. Brown by taking sparks on to a photographic dry plate and then developing. Bring the knob nearer and nearer, the same thing happens, until the water is touched by the knob, and even after it is submerged. But as soon as the metallic conductor is submerged the ramifications get less and less vigorous, and when a sufficient surface is immersed they cease. I have never seen these ramifications spread of themselves *below* the surface of the water. They appear to me to keep entirely to the surface. But I have not yet finished investigating these appearances.

13. Immersing a half-full beaker in the water, sparks can be got to the water inside it, though they prefer to curl round and go outside. The noise the sparks make when they go inside is a curious one, and sounds as if the glass cracked each time, but it does not. If the glass is moist, a brush cascade round its edge can be seen in the dark. If it be dry, the water inside gets charged, and fizzes audibly back to the knob for a second or so after the spark has ceased, a dimple being visible in the water below the knob.

14. Live things in the struck water—worms, flies, fish, etc.—will most certainly get struck; but so they do under far less violent disturbances than what they would here be subject to. There is nothing surprising in the fish of a pond or lake being killed by a flash of lightning; and it has often happened. When H.M.S. "Conway" was struck many years ago, and protected by its lightning-conductors, it is related that the sea-water was seen to be luminous on all sides of the ship. This is exactly the effect I now imitate.

15. There is one more experiment on discharge in water which I have just tried, and which it is interesting to show.* I take a pointed rod, and, protecting it by a glass tube, immerse its point under water in a beaker containing a plate connected to the other coat of the jar, and pass a spark. With the point negative, there is a bright glow region round it every time, but the discharge is quiet. With the point positive, the flash is of a dazzling white, and is accompanied by a great deal of noise and violence, threatening to smash the Leyden jar, and throwing down the copper plate towards the bottom of the beaker with fury.

Oscillatory Character of Lightning.

16. Before leaving the outdoor department of our subject, I must say a few words on one branch of it concerning which there is evidently considerable uncertainty and haziness abroad—I mean the oscillatory character of a lightning flash. That a Leyden jar discharge is usually oscillatory must now be regarded as so extravagantly proved that any doubts that may have existed on the subject must surely by this time be cleared away, at least for the case where the discharge has to utilise a wire circuit. But perhaps it is still doubted for the case when a jar overflows its edge, or, still more, when it merely sparks through its own dielectric, straight between the coatings. Now, as I have insisted all along, a lightning flash is a spark through the dielectric of a jar whose two coatings are either two clouds, or else cloud and earth. Hence, if any importance is attached to the fact (as I believe it) that lightning flashes are oscillatory, it is necessary to prove it for a Leyden jar sparking direct between its coatings, especially when the coatings are not very close together.

* This experiment was not shown at the meeting because in trying it over in the afternoon the protecting glass tube was electrically broken.

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17. The reason I do attach importance to the oscillatory character of a discharge is because I have worked out the quantitative behaviour of conductors on that aspect of the matter; and though, as Prof. Fitzgerald said at Bath, everything would hold just as well for a single oscillation—viz., one violent rise and decay of current (which without any doubt must accompany a lightning stroke or any other quick discharge whatever)—if rapid enough, yet the rapidity of such a charge as this does not seem to me probably at all sufficient to account for some of the effects. The rapidity of variation of current in that case would be directly connected with the total duration of the flash; and though we have evidence that it is very momentary, yet we have no evidence that it is so instantaneous (say a millionth of a second) as the semi-period of one of the oscillations may be, a dozen or more of which may accompany an entire flash. However, I admit, of course, that all I want is a tremendously rapid variation of current; and if I can be given this by one oscillation, the rest are unnecessary, and may be dispensed with.

18. When I speak of the oscillatory character of a flash, let it be understood once for all that I do not mean in the least such a thing as can be analysed by waggling the head. Flashes analysable by waggling the head must be multiple ones, and the interval of time between their constituents (which may be, say, the fiftieth of a second or thereabouts) is a long period compared with that of an oscillation such as I mean, bearing the same sort of ratio to it as a quarter of a century bears to an hour.

19. A direct experimental proof that lightning is oscillatory will be obtained when photographs of it are taken on a sensitive plate revolving 1,000 times a second. Something short of that speed would cause the image of the flash to blur, but that speed might be sufficient to analyse out the oscillations, when examined carefully with a magnifier, the focussing being good. Till then the easiest proof that it is oscillatory is a theoretical one, and it can be put in a few words.

20. Consider an air condenser with two coatings, each of area A, separated by the distance h, and let it burst its dielectric. It is well known that the discharge is oscillatory when the whole resistance met with by the discharge is anything less than a critical value.

$$R_0 = 2\sqrt{\left(\frac{L}{S}\right)}.$$

Now, attending only to the straight part of the discharge, and ignoring the current rushing up in the plates to the spark path, the self-induction of a straight conductor of length h and sectional radius a is very approximately $L = 2\,\mu\,h \log \frac{4h}{a}$.

The capacity of the discharged condenser is $S = \frac{KA}{4\pi h}$.

Hence the critical resistance which must not be exceeded is given by

$$R_0^2 = \frac{32\,\pi\,\mu\,h^2}{KA} \log \frac{4h}{a};$$

or

$$R_0 = 10\,\mu\,h\,\text{“}v\text{”}\sqrt{\left(\frac{1}{A}\log\frac{4h}{a}\right)}$$

$$= 300 \text{ ohms} \times \sqrt{\left(\frac{1}{A}\log\frac{4h}{a}\right)} \times h.$$

The important thing to notice in this value of $\sqrt{\frac{L}{S}}$ is that it is approximately proportional to the first power of h, the distance between the plates of the condenser.

21. Next consider the resistance of the discharge path. It, too, will be proportional to the length h, and it may be written $R_1\,h$, where R_1 is the resistance per unit length of the discharge path.

The condition for oscillation, then, is that this $R_1\,h$ shall be less than R_0; or *the resistance of unit length of the spark must be less than* 300 ohms $\times \sqrt{\left(\frac{1}{A}\log\frac{4h}{a}\right)}$.

22. The term under the square root will take different values according to circumstances, and it may be greater or less than 1 per metre. Ordinarily, however, it will be greater than 1 per metre, unless the area of charged surface is considerable. The important thing is the way in which h, the distance between the plates, enters into the expression. It does not come in very prominently at all, but so far as it does influence the result it permits the discharge to be oscillatory more easily when the plates are a good distance apart than when they are close together.

23. Take a couple of typical examples. First, a Leyden jar bursting its glass. A fine needle may be just put through the hole usually made in these cases, so we can take the sectional radius, a, as something like a tenth of a millimetre. The thickness of the glass may be two millimetres, hence $4^h/_a = 80$ or thereabouts, and the natural logarithm of this is about four. Suppose the area of coated surface is half a metre square, then the critical resistance which a metre of the spark must not exceed is 1,200 ohms, and so the two millimetres of it must not exceed 2·4 ohms. It is difficult to say whether this is or is not a large resistance for such a short spark, and hence it is difficult to be sure that such a spark is anything more than a mere one-directional discharge. To go into it more fully, the currents in the metal coatings would have to be considered. Next, take as example a cloud area at an elevation of one kilometre; and because a lightning discharge usually makes perforations of fair diameter, we may suppose a to be about a millimetre. (A widely erroneous estimate in this quantity makes but little difference in the result.) In such a case $4^h/_a = 4 \times 10^6$, and the logarithm of it is between 15 and 16. Hence the charged area may be 15 or 16 square metres without bringing down the square root term below 1 per metre; so the resistance of the whole flash may in that case be anything below 300,000 ohms without checking the oscillations. The discharged area may indeed be as much as 1,500 square metres without bringing the critical resistance which the flash must not exceed below 30,000 ohms, or 30 ohms per metre. Understand that "resistance" here does not mean impedance. It means true dissipation of energy resistence (section 25), and the current squared is so enormous (section 29) that the resistance-coefficient may be quite small. In another place (*Phil. Mag.*, August, 1888) I have shown reason for believing that the area of cloud discharged at any one flash is usually very moderate; and hence, on the whole, I consider it proved, so far as elementary theory can do it, that the lightning flash usually takes place under conditions favourable to oscillation.

24. And these oscillations are extremely rapid. The rapidity depends on the inverse geometric mean of L and S, and this is practically almost independent of h. Referring back to their values, we see that

$$LS = \frac{\mu K A}{2\pi} \log \frac{4h}{a};$$

and so the number of complete alternations per section is

$$\frac{\text{“}v\text{”}}{\sqrt{\left(2\pi A \log \frac{4h}{a}\right)}},$$

which, in the second example of section 23, with A as 100 square metres, becomes three million per second. If the discharged area were as great as 10,000 square metres, the rate of alternation would still be a third of a million per second.

(To be continued.)

THE TRANSMISSION OF POWER BY ELECTRICITY.*

BY FRANK J. SPRAGUE.

(*Concluded from page 313.*)

Referring to the equation (10) and substituting for m approximate value, 10·5, and for d its value, ·00000302705 we have:

$$v = \cdot 308\, l \sqrt{\frac{b\beta}{K+L}} \quad . \quad . \quad . \quad . \quad . \quad (17$$

Combining this with (13), we find that

$$E = \frac{\cdot 308\, l\, \lambda}{a\beta - \lambda} \sqrt{\frac{b\beta}{K+L}} \quad . \quad . \quad . \quad . \quad . \quad (18$$

We now see what influence the cost of copper has when the commercial efficiency is maintained constant, which is to vary the value of E as it increases, but only as the square root of such increase. It will be noticed also that a variation in K + L inversely affects E and v likewise as the square root.

It follows from the above that if we do not limit ourselves in the E.M.F. use, the cost per horse-power delivered exclusive of line erection is, for least cost and for a given commercial efficiency, absolutely independent of the distance.

We are met at times with the condition that the motor potential shall not be above a given amount, and from the formula,

$$E = \frac{\cdot 308\, l\, \lambda}{a\beta - \lambda} \sqrt{\frac{b\beta}{K+L}}$$

transposed to

$$\lambda = \frac{E\,a\,\beta}{\cdot 308\, l \sqrt{\frac{b\beta}{K+L}} + E} \quad . \quad . \quad . \quad . \quad (19)$$

* A lecture delivered before the Franklin Institute, November 12, 1888.

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we find at once what the efficiency of the transmission must be with a given distance, and therefore whether it is worth while to attempt the operation. On the other hand, if, for example, we make our lower limit of commercial efficiency 50%, $a\beta$ = 80%, and β = 90%, we have a limiting equation.

$$E = \cdot 487 l \sqrt{\frac{b}{K+L}} \quad . \quad . \quad . \quad . \quad (20)$$

Since the circular mils. vary inversely with E v, the size, weight, and cost of the wire vary directly as the cost of the generating plant, which we have already seen from another formula. To get a matter-of-fact idea of this, I will assume some values, as follows :

Let K = \$45.00, L = \$20.00 (say for a water-power), M = \$50.00, and b = 25 cents for copper delivered on the ground.

Then we would have our formulæ for this particular case reduced to the following :

$$v = \frac{4 - 5\lambda}{5\lambda} E \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21)$$

$$v = \cdot 0181 l \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (22)$$

$$E = \frac{\cdot 0905 \lambda}{4 - 5\lambda} l \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (23)$$

and

$$\lambda = \frac{4 E}{5 E + \cdot 0905 l} \quad . \quad . \quad . \quad . \quad . \quad (24)$$

which will give us the required elements of any single transmission under these conditions.

For example, suppose we wish to transmit 20,000ft. The fall of potential on the line could be 362 volts, and this is independent of the commercial efficiency. If this latter is made, say, 60 per cent., then E = 1,086 volts, and the potential at the terminals of the generator should be 1,448 volts. On the other hand, suppose we want to transmit a distance of 10,000ft. with a motor terminal potential of 800 volts, then λ = 65 per cent., and v = 181 volts.

We can, as I will soon show, make a graphic representation of these facts, which will save much labour and will give at a glance the various limitations.

Referring to the general equation, we can make, for various efficiences, a table as follows :

$$\lambda = 50\% \quad C = 2K + 2L + \tfrac{3}{4}(K+L) + M + \frac{P}{n}$$

$$55 \;,, \quad ,, \quad \tfrac{20}{11}K + \tfrac{20}{11}L + \tfrac{25}{44}(K+L) + M + \frac{P}{n}$$

$$60 \;,, \quad ,, \quad \tfrac{5}{3}K + \tfrac{5}{3}L + \tfrac{5}{12}(K+L) + M + \frac{P}{n}$$

$$65 \;,, \quad ,, \quad \tfrac{20}{13}K + \tfrac{20}{13}L + \tfrac{15}{52}(K+L) + M + \frac{P}{n}$$

$$70 \;,, \quad ,, \quad \tfrac{10}{7}K + \tfrac{10}{7}L + \tfrac{5}{28}(K+L) + M + \frac{P}{n}$$

$$75 \;,, \quad ,, \quad \tfrac{4}{3}K + \tfrac{4}{3}L + \tfrac{1}{12}(K+L) + M + \frac{P}{n}$$

$$80 \;,, \quad ,, \quad \tfrac{5}{4}K + \tfrac{5}{4}L + \quad o \quad + M + \frac{P}{n}$$

and substituting the assumed value of K, L, and M, we would have for the cost of transmission per horse-power delivered, exclusive of poles and line erection, and independently of the distance, the following table :

Efficiency, Per Cent.	Water-power.	Dynamo.	Wire.	Motor.	Electrical Total.	Water and Electrical.
50	\$40 00	\$90 00	\$48 75	\$50 00	\$188 75	\$228 75
55	36 36	81 81	36 94	50 00	168 75	205 11
60	33 33	75 00	27 08	50 00	152 08	185 41
65	30 77	69 23	18 75	50 00	137 98	168 75
70	28 57	64 28	11 61	50 00	125 89	154 46
75	26 67	60 00	5 42	50 00	115 42	142 09
80	24 00	56 25	—	50 00	106 25	130 25

The graphic representation of the facts which have been set forth, and the construction of an electrical reference table, which will at once show the necessary elements, is a simple matter.

We have the quotation,

$$E = \frac{\cdot 0905 \lambda}{4 - 5\lambda} l$$

Let us lay off on the axis of x the distance in feet, and on the axis of y the E.M.F. at the motor terminals.

Then for any value of λ the ratio of

$$\frac{E}{l}$$

is fixed, whatever the actual value, and we can draw the efficiency lines, O A, O B, etc., for

$$\lambda = 70\%, 60\%, \text{etc.},$$

which will, with the different values of l and E, give us any required information. This, however, is not yet in a convenient and general form, and we wish to get some general intersecting efficiency line. By an inspection of the diagram we see that if a general efficiency line can be drawn it must intersect the specific efficiency lines at such an angle that the intersected portions must be proportional to the differences of efficiencies. In other words, we must have the ratio

$$\frac{E}{\lambda}$$

for any particular value of E constant. Referring to the above equation and transposing, we have,

$$\frac{E}{\lambda} = \frac{5 E + \cdot 0905 l}{4} \quad . \quad . \quad . \quad . \quad . \quad (25)$$

It is evident that if we are to get this equation to give a straight line, we must make the condition

$$\frac{E}{\lambda}$$

a constant, r. Substituting we have—

$$\frac{E}{\lambda} = r$$

and

$$r = \frac{5 E + \cdot 0905 l}{4}$$

which will give in a series of parallel straight lines for various values of r and E corresponding.

Let $r = 1{,}000.$

Then we have— $E = 1{,}000\ \lambda$

and $E = \dfrac{4r - \cdot 0905 l}{5}$

when E and $\lambda = 0$, $4r = \cdot 0905 l$

or $l = 44{,}199,$

and when $l = 0,$

$E = 800$

and $\lambda = 80\%.$

Plotting this, we have a general efficiency line. Assuming another value for r, we get another straight line parallel to this, but one line is sufficient. It is, however, of prime importance. On it we lay off the efficiency percentages in equal increments, from 0 to 80%, and the chart which needs consist only of the axes of x and y, on which the E.M.F. and distance are laid off, and the efficiency intersecting line is ready for constant reference, and will give at a glance the graphic solution of all the ordinary elements of a transmission under the condition of least prime cost, and with the known efficiency of motors and dynamos. For example, suppose we wish to transmit a distance of 30,000ft. at a commercial efficiency of 60 per cent., what would be the required E.M.F. at the motor terminals? Drawing the efficiency line O B till it meets the ordinate erected at l = 30,000, we find the E.M.F. to be 1,620 volts. On the other hand, suppose we are limited to 1,000 volts at the motor, and must have an efficiency of 50 per cent., what would be the limiting distance? Reversing the above process, we find it to be 33,500ft. Suppose, again, that we must operate at a distance of 20,000ft., and are likewise limited to an E.M.F. of 800 volts at the motor, what would be the required efficiency? Through the intersection of the co-ordinates of E.M.F. and distance, we draw the efficiency line O H, and at its intersection find the efficiency to be about 55½ per cent. Such, then, is this method of graphic determination.

Commercial practice, however, may make it inadvisable to meet every phase of a transmission just as the theory may demand, and since in manufacture it may be advisable to build motors for three standard potentials—say, for 400, 800, and 1,200 volts, allowing the dynamo to be driven at the E.M.F. demanded by theory.

At the end of the paper is given a table of "illustrative rather than perfectly accurate" prices, but any English reader must take prices as they rule at the point where the machinery is to be used, and, in fact, construct estimates for each particular piece of work.

UNDERGROUND CONDUITS AND ELECTRICAL CONDUCTORS.*

BY JOHN B. VERITY (MEMBER).

(*Concluded from page 339.*)

It is underground conductors for high-tension currents that I propose now to deal with. A principal point for consideration is the necessity, or not, for lead sheathing where conduits or ducts are employed.

As to the durability of lead, much absurdity has been talked. It is notorious that lead pipes have been in the ground under all manner of

* Paper read before the Institution of Electrical Engineers.

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conditions, and at the end of long periods are still intact. There are no doubt certain clayey soils where lead has not much lasting power, but the lead may be materially preserved by coating it with coal tar, well tapeing it, and again soaking it in the coal tar or some such protective composition. Again, as Dr. W. von Siemens recently said in reply to Prof. Forbes' paper, the manner in which the lead covering is generally put on to such cables—viz., by heating the lead to the point of melting, and forming it in this condition round the cable, while passing through the press—there is no certainty of a uniform thickness, and it is very difficult to obtain a tube through which damp, in course of time, will not find an entrance, as air bubbles and impurities in the lead are liable to make the covering porous. A far better result is obtained by covering the insulated cable with a cold drawn lead tube, as the air which might still be contained in the lead block is compressed to a minimum.

A theory as to partial wasting of lead covering on cables is that it may occur from acid being present in the jute or fibrous insulation, or, again, that the petroleum residuums may set up a chemical action on the lead; but there has not been much evidence on these points. Manufacturers of lead-covered cables have admittedly put on too thin a coating of lead in the earlier days; this has been gradually increased, and with proper conditions and precautions there should not be much fear of its durability.

Iron-armoured lead-covered cables are not necessary if an effective system of conduits is used for mechanical protection. In Berlin, where such cables are employed, they are simply laid in a trench in the ground, and consequently require to be thoroughly protected from mechanical injury. Lead alone is not sufficient.

Dr. Werner von Siemens said in his recent paper that long years of experience had taught him that, although covered with hemp or jute, it requires further protection to render it secure against mechanical injury, whether by men or animals, as even rats eat their way through. Such protection is afforded by a double spiral of sheet iron, which again is made secure against oxidation by asphalting or galvanising, or by another cover of tarred hemp or jute. Such armouring as this is quite needless with a well-constructed conduit, but as to whether galvanic action takes place Dr. Siemens has undoubtedly shown by his firm's experience that with a substantial layer of tarred or asphalted jute between the metals it does not occur. This form of armoured cable was laid at Munich for lighting the theatre, and after nearly five years in the ground is as perfect as at first. At other central stations at Elberfeld, Darmstadt, Geneva, Salzburg, Lyons, the Hague, St. Petersburg, their iron-armoured lead-covered cables prove that constructed in this way there need be no fear of galvanic action at any rate.

Lead sheathing may be made durable, but the actual necessity of it where a conduit is used is quite another matter, and a consideration of the two principal divisions of insulating material has considerable bearing on this point.

Of the fibrous and the homogeneous the latter seems to present some important advantages for insulating high-tension cables. For instance, vulcanised rubber is flexible and tough, and affords a continuous and homogeneous covering which should be superior to a fibrous covering. Vulcanised rubber cables are at times sheathed with lead for mechanical protection, but such is not necessary if laid under good mechanical conditions, and Mr. Lant Carpenter recently said that the sulphur in the vulcanised rubber would attack the lead in the same way it would copper. If, as is stated by many English cable manufacturers, compound vulcanised rubber will well withstand the deteriorating effects of damp and gases, then, the mechanical protection being afforded by a conduit, the necessity of lead as a protector is no longer of importance. It is true unprotected vulcanised rubber cables in conduits have failed in the States, but the competition among electric light companies in America is notorious, and the question as to the maintenance of cables is not considered so much as their relative first cost. The object of the American cable manufacturers, naturally suiting their market, has been to make cables with a cheap form of vulcanised rubber insulation to compete with the jute-insulated cables there, and which are cheaper. The vulcanised rubber evidently was not properly prepared as it should be to permanently counteract the deteriorating effects of damp and gases by reason of the expense.

All those acquainted with the rudiments of rubber manufacture must be aware of the enormous difference in quality of different vulcanised rubbers. With Para rubber at 3s. per lb. and the desire to sell it at a shilling, all manner of substitutes and compounds have been introduced. While thoroughly appreciating the energy and genius of American electricians, we can confidently say that cables manufactured in this country are greatly superior to those made in the United States; and as a basis for this belief we have the fact that most of the cables for high-tension distribution in the States have proved faulty, according to their own admittance, while there is undoubted evidence of the successful working of many vulcanised rubber and jute-insulated cables in this country and in Europe, made by English manufacturers. The statement is made by the Silvertown Company, Messrs. Henley and Co., and others, that they are absolutely prepared to guarantee for a term of years their vulcanised rubber cables unprotected by lead, even if laid in damp and leaky conduits, provided there is suitable mechanical protection against injury and that the cables are laid under competent supervision.

With regard to *fibrous* insulating material it is alleged that it has the defect of opening cracks when bent. If this be the case it would become more pronounced when the material is soaked in resinous compound, and perhaps less so when petroleum residuums are used—such as, for instance, in ozite, kerite, bitite, etc. If cracks are likely to be formed when the cable is bent or twisted about, air paths would be opened up for disruptive discharges.

In the working directions given for the laying of one of the principal lead-covered cables in the States, it says "the fibrous material, being super-dried, will readily absorb and retain moisture from the air, and cables showing an insulation resistance of thousands of megohms when first made may, after exposure of a small part of the core to moist air for a few hours, show a great falling off of insulation resistance." Instructions are therefore given as to carefully sealing the ends of the cable when laying. Again, the splicers' hands are cautioned to be kept "perfectly dry and free from perspiration, as a little moisture communicated to the insulation may result in vastly lowering the insulation resistance." These remarks written by manufacturers of such cables show the readiness with which such fibrous insulation may deteriorate under conditions likely to occur even if there be the most careful supervision of the men laying the cables. It is acknowledged to be absolutely necessary to cover jute or cotton insulated cables with lead, and it is in this fact that the weakness of such cables seems to lie, as the moisture and gas resisting portion is the lead absolutely, the jute insulation being of little value in this respect.

Inasmuch as the majority of underground cables in the States are insulated with such jute or cotton soaked in some compound, it will be at once understood why lead-covered cables are considered in America as the only means for successfully carrying out such underground cable work, especially when the cables are liable to be laid in leaky conduits. It is right to say that apparently few troubles have been experienced in Europe with underground conductors insulated with fibrous material. Messrs. Siemens and Halske, who use a jute-covered cable, but manufactured in a different way both as regards the impregnating of the jute and the method of cold drawn lead sheathing, have a successful record, not only for low-tension cables, but for the various concentric cables supplied to Messrs. Ganz Company, of Buda-Pesth, for 2,000 volt alternating currents. They assert that the troubles experienced with American underground cables, whether jute or rubber insulated, are comparatively unknown.

The question between what I broadly term lead-sheathed jute or well-compounded vulcanised rubber seems to me the momentous one, and, as usual, each one has certain claims.

It is well known that the cost of jute-insulated cables is less than that of high-class vulcanised rubber insulation, but this would have little weight unless they can be proved in every respect equal to vulcanised rubber. In a comparison of the different costs of such insulation, vulcanised rubber appears to be about 25 per cent. more for approximately the same insulation resistance. In making this comparison I took the cost of a vulcanised rubber cable, insulated with one layer of so-called pure and two coatings of vulcanised rubber, taped, braided, and coated with preservative compound, but not covered with lead, as this is a superfluity, the cable being water-tight without this addition. The jute-insulated cable I took as cased with lead, and protected again by a covering of tarred jute yarn compounded.

After the relative cost comes the question of jointing, and as this is one of the most vulnerable points in any cable it is of vital importance that the joints should be made as good as any other part. With vulcanised rubber cables the joints must be vulcanised, and first-class rubber men, who would make such joints speedily, should be on the working staff. With lead-covered cables a plumber would have to be employed; and I am informed by those who have had experience with both forms of cables that the vulcanising is preferable to the plumbing.

Vulcanised rubber cables are certainly easier to handle, being more flexible, ductile, and lighter; and this is of importance in view of the difficulties occurring in drawing cables in and out of a conduit.

Again, when lead-covered cables are coiled round a drum, the part nearest the centre becomes compressed, while the outer portion is extended. On uncoiling the cable the opposite effect is produced, the parts before compressed being now pulled out, and the extended portion compressed. This is trying to an inelastic substance like lead, the more so when, unlike an empty lead pipe for water, it is filled with an insulated cable. It is quite conceivable that the surface of the lead may be slightly broken up, particularly when the method employed is to cover the lead hot round the cable, and although no cracks may be visible to the eye, gas and moisture might be apt to find their way in very quickly, with corresponding deterioration of the insulation.

Next, as to whether jute or vulcanised rubber is better suited for insulating high-tension alternating cables no opinion can yet be given. It is well known that on submarine cables working with reversed currents, it is usual at times to give the cable a rest. This necessity may be due to the action of the reversed current on the insulation, and it would be interesting to know how the much more powerful currents and rapid reversals of an electric light circuit will affect the insulation of a cable after carrying such currents for a considerable period. In some interesting papers, published last year by Mr. Addenbrooke, he came to the conclusion that a high-tension alternating current should have less effect on any dielectric than a continuous current of the same potential. He argued that, owing to the rapid alternations, there would not be sufficient time to fully charge the dielectric, as, before this could occur, the next charge would sweep out the former charge, partially recharging it in the opposite direction. But it would certainly appear that such an action as this on a dielectric would be far more injurious than for it to be fully charged as with a continuous current.

From a careful review of what I have seen in the States and elsewhere, I must confess that my own feeling is in favour of a cable insulated with thoroughly good vulcanised rubber for high-tension work, and I was interested to hear Sir William Thomson say on Monday, at the Board of Trade enquiry, that if high-tension conductors were protected in an iron pipe a lead sheathing to them was not essential.

Those acquainted with the present manufacture of rubber cables know that pure rubber proper is not used for their insulation. How-

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ever good the rubber may be, there is always a certain amount of impurity and oils which will set up decomposition sooner or later. This is overcome by slightly vulcanising the rubber, but so that there shall be no surplus sulphur to attack the copper. In the high-class cables now made by the Silvertown Company and others, the practice is to put next the conductor, after cotton twist, a substantial coating of pure indiarubber, slightly vulcanised, upon this a coating of zinc rubber, with vulcanising materials, and, covering this, a compound vulcanised rubber of great resisting qualities to damp and gases. The zinc rubber takes up the surplus vulcanising material of its two outer coverings, so that the copper cable is not injured by the sulphur used in the process. Such an insulation as this is as good as could possibly be desired for any high-tension currents, and is absolutely perfect so long as the covering is continuous, and as the whole of the materials are treated at a temperature of 400deg. any rise in temperature of the conductor due to accidental overloading will not injure the insulation. With regard to the outer protection of the compound vulcanised indiarubber, there may be still scope for further improvement, and, for instance, in the cables recently made by the Silvertown Company for the London Electric Supply Corporation, two braidings of asphalted tape have been used, and this is found to be satisfactory. Among the instances where vulcanised rubber cables have stood stringent tests has been at Eastbourne, where Mr. Lowrie has used Silvertown cables, laid in iron pipes, for two years, and states they are still in perfect working order. He has also put down there a length of Fowler's Tatham lead-covered cable for continuous-current high-tension work, the fibrous insulation being well wrapped round several times with tape. This has also been working successfully, and in the House-to-House Company's station he proposes to try each method of insulation on different circuits, although the advantages of handling the indiarubber cables are in their favour.

The Silvertown Company have five miles of vulcanised indiarubber insulated cable sheathed with iron wires at Brussels, with 1,400 volts constant current. This was laid in the sewers two years ago, and is now quite satisfactory.

This company have also supplied two miles of such cable, but with asphalted tape on the outside, to the London Electric Supply Corporation, with 2,400 volts alternating current, the conductors being laid in an iron pipe.

There are also samples on the table of a piece of Messrs. Henley's vulcanised rubber cable that has been in use overhead for 10 years.

A difficulty with underground conductors in the States seems to be disruptive dicharges, and I trust the discussion may bring forth information on the subject. Owing to the frequent puncturing of the insulation, attended with pinholes in the lead covering, Mr. Ascherson, the Waring Company's able electrician, and whom I desire heartily to thank, turned his attention to the matter, as the pinholes by admitting moisture defeated the object of the lead sheathing, and proved fatal to the life of the cable.

Mr. Ascherson's theory is that the static electricity generated in the cable after a time punctures the dielectric by discharging itself between the copper conductor and the lead sheathing ; and the protector shown in Fig. 13 is designed to obviate this.

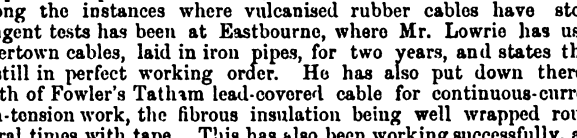

FIG. 13.

This consists of two metallic points, separated by a distance which is less than the thickness of the cable insulation. The one point is connected to the lead sheathing, and the other through a fuse wire to the copper conductor, the idea being that the static discharge would take the shorter path between the points instead of rupturing the insulation. Mr. Ascherson says these dischargers should be placed at every section of a cable, and if the sections are more than 200ft. long there should be one at each end.

To show the exceedingly minute path necessary for a discharge, it may not be out of place to quote Mr. Ascherson's experiment. A plate of glass about one-tenth of an inch thick was broken in two pieces, and the two parts immediately fitted to their former position and clamped ; the restored plate was placed between two discharging points, and so long as the points were over the solid glass no discharge was obtained, but upon removing it, so that the line joining the points would lie in the plane of the fracture, a discharge immediately occurred.

A possible cause of a disruptive discharge might be that on high-tension circuits of great self-induction, as, for instance, on arc-lighting circuits, where lamp coils form part of the line, the induced current on breaking the circuit is very violent, and in preference to discharging through the line, and consequently the lamp coils, it gets away by rupturing the weak insulation and passing through to the outer earthed casing.

The exemption from such trouble is credited by many entirely to a thicker insulation being used, and in calculating the insulation for a high-tension cable it should be made sufficient to withstand a disruptive discharge of this nature and tested accordingly. For instance, owing to the almost daily occurrence of burn-outs with some cables in Chicago with $\frac{3}{32}$ insulation laid in November, 1887, the four miles laid in December, 1887, had $\frac{4}{32}$ insulation, and the two miles laid early in March, 1888, have $\frac{6}{32}$ insulation. Careful experimental work is essential before the sufficiency of insulation for such underground cables can be accurately determined, and our leading cable manufacturers naturally keep the results of such experiments to themselves.

Concentric cables, although so extensively used by Messrs. Ganz, of Buda-Pesth, in their stations, do not appear as yet to have met with favour in the States. It is, of course, undesirable to use ordinary lead-covered cables for alternating currents, both on account of the loss from induced currents in the lead sheathing and the annoyance to workmen handling them. If, for instance, while handling a conductor conveying such a current the lead covering be insulated to any extent on each side of them, the workmen would receive the induced currents through their bodies. Again, when the two lags of an alternating current are in separate cables, and the cables laid in insulating materials, any chance contact or connection between the leads might cause the induced currents to pass backwards and forwards at these points, thus tending to cut away the lead covering as the result of any sparking at poor contacts between the two leads. The Waring anti-induction cable, with both wires enclosed in one sheathing, is well known, and in this the currents induced by both wires, being equal in power and opposite in direction, tend to neutralise one another.

Mr. Ferranti, by employing concentric cables for conveying the high-tension currents from Deptford station, has brought such cables into prominent notice in England. A concentric cable is obviously the best on theoretical grounds for the elimination of induced currents, as their reaction upon one another is necessarily strongest in the axis of the current. The question as to the necessity of insulating the outer conductor of the concentric cable has recently had considerable attention give to it by Mr. Preece on behalf of the Post Office authorities, and as a result of his experiments they evidently must be so insulated. All the concentric cables made by Messrs. Siemens and Halske for Messrs. Ganz and Co. are of the usual stranded wire form, and the outside conductor, after being well insulated with jute, is covered with a cold-drawn lead tube, having an outer iron armouring as previously described. These cables have been successfully used in Rome, Tivoli, Turin, and Milan, in each case carrying a potential of 2,000 volts.

The difficulty of making satisfactory joints with concentric cables must be to a certain extent against them, as it is impossible to see what has been done inside. Messrs. Siemens say that it can be readily accomplished, and the illustration shows the manner in which the joints are made in their cables. The Silvertown Company have made several forms of concentric cables, highly insulated with vulcanised rubber, with considerable success for ship work, and they also have an arrangement for constructing the joints.

As to whether concentric cables will be largely used in this country much depends upon the system of distribution employed. For long lengths of cable used as feeders to sub-centres, or to systems of distributing mains, they would be of considerable advantage, as no joints would be required *en route*, but in house-to-house distribution, with frequents joints, a pair of separate cables near to each other would appear the more easy to handle and the more practicable to operate. In summing up this matter it would appear that the relative advantages are as follows : 1st. The greater convenience of making joints on separate leads as against the trouble involved with concentric cables. 2nd. As regards the relative cost between two separate cables and concentric cables with the same insulation resistance, vulcanised rubber unsheathed concentric cables with outside insulation are dearer, but with jute insulation for concentric cables and lead sheathing they are cheaper. 3rd. There remains the increased efficiency on an extensive system of alternating currents by the use of the concentric form.

With regard to the second point, the figures showing these are : For vulcanised rubber, two Silvertown $\frac{7}{16}$ conductors insulated to 5,000 megohms at 60deg. F., taped and braided over all, specially prepared for underground work, £255 per mile each = £510.

A concentric conductor of equivalent capacity, the internal conductor insulated to 5,000 megohms, as above, but the outer to 3,000, only = £900, being a difference against the concentric conductor of £390 per mile. If the outer insulation is reduced to 1,500 megohms, the price falls to £630 per mile, which is £120 above the cost of separate leads.

On the other hand, for Messrs. Siemens' specially prepared jute insulation two single conductors of same insulation at £220 per mile each, £440.

A concentric conductor of equivalent capacity, the outside insulated to 900 megohms, lead sheathed, taped and asphalted, £363 per mile.

All cables for high-tension currents should be well tested before leaving the factory. In other branches of engineering the engineer would not think of receiving his steam or hydraulic pipes without first seeing them tested to, say, over twice their working pressure. It is not sufficient for him to see simply that they will hold water or steam, but he must satisfy himself that they are strong enough for the pressure they have to carry. In the same way the electrical conductors which have to transmit energy, much as the steam and hydraulic pipes do, should be tested to twice their working pressure. With the outside well-earthed current should be allowed to traverse the conductor a considerable time, and an electrical test taken afterwards for insulation. With electrical cables for underground work passed in this way, and satisfactory in other respects, there should be no fear of breakdowns under ordinary conditions.

In dealing with a subject of such wide extent and great importance as this, it is impossible to do justice to all the workers in the field. I have left out much that may be considered interesting and important, but the difficulty has been, with the mass of imformation on the subject, what to put in and what to leave out. Doubtless there are many instances of cables and conduits having been successfully at work which have not been mentioned in this paper, and I hope such information will be forthcoming. If the discussion following be the means of clearing up some of the doubtful points surrounding the subject of underground electrical work, and of demonstrating the direction in which successful work should be undertaken, the object of this paper will be fully accomplished.

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had told them, on the banks of the canal. For that work £30,000 would be ample. Their intention was to make similar arrangements for the districts of St. Martin's and the Strand. The capital expenditure proposed by Prof. Forbes would be equal to £2. 4s. per 30-watt lamp fixed, or £3. 6s. running. Those figures, compared with £1. 12s. per lamp fixed, and £2. 8s. per lamp running, of the E.P.S. system. Two pounds eight shillings per lamp running was the most economical limit at which the E.P.S. system could be carried out, and he had allowed a margin, leaving it at £3 per lamp in his estimate of £30,000.

Mr. Russell Griffiths then opened his case on behalf of the Commissioners of Sewers for the City of London. He said that on their behalf he had to object to the application of both the London Electric Supply Corporation and of the Metropolitan Company for provisional orders for the City of London. There were three main grounds on which he objected to the orders. One was that the Commissioners of Sewers, who had been in existence since 1848, and who had hitherto had the lighting of the City, were quite capable of conducting their own affairs. The Sewers Act, which was an Act of 1848, constituting those Commissioners, gave them, by the 116th section, express authority to enter into such contracts with such gas companies and other persons as they might think fit, to supply gas, or to light the City by any other mode, and also it gave them express authority to inflict such fines or penalties as they might think fit where such contracts as they entered into were not faithfully carried out. Those powers were subject, as all powers must be, to Acts of Parliament, which might give rights to other companies to come in and deal with such matters. He was not going to contend that the Commissioners of Sewers would not be bound by such Acts as Parliament thought fit in its wisdom to make. What he did claim was that they had sufficient facilities given to them to contract for public and private lighting, and that they were persons who, as he would show, by their acts hitherto, and the way in which they had dealt with gas and electricity up to this time, ought to be entrusted with the lighting of the City of London. What he proposed at present, therefore, was to ask the inspector to consider the powers of the Commissioners from a local point of view, and what these two orders sought to impose upon the City—the obligations which they sought to impose and the corresponding benefits which they put forward as coming to the City if they were allowed to have those Parliamentary powers. He did not propose in any way or as little as he could to contrast the relative advantages of the two proposed systems of supplying electrical energy which had been detailed by so many scientific witnesses. He was quite content to take what his learned friend Mr. Moulton had said about the difficulties that the alternating system would have to contend with, in fact, the scientific difficulties that the two companies would have to overcome before they could be safely entrusted to go into a very compactly inhabited district. As to the second ground of objection, he thought he had better take it separately as regarded the two companies, because although they both intended to use the transformer system, they intended to use it under very different conditions, and he would deal with each of the companies not very exhaustively, but sufficiently for his purpose, to show that there were difficulties in each of their systems, and that in neither case ought the Board of Trade to impose on the City the rights claimed by those companies, and the corresponding inconveniences which the inhabitants would have to put up with. There had been some doubts expressed by several of the witnesses as to the feasibility of having such a generating plant as that proposed for Deptford. They had the extraordinary evidence that the engines of 10,000 h.p. would be equal to what supplied 120 installations in America, so that if the Americans had hitherto been credited with being a go-ahead people they would have to hide their diminished heads in the matter of electricity. He submitted that that was an entirely unsafe power to use in generating electricity. The generating station was situated at some distance from London, and all the plant being under one roof formed practically one generating unit for the supply of electricity, and he submitted that that was a source of great danger. There was no possibility of storage, and it would be very unsafe for the City to depend for its supply of light under such circumstances. The trunk mains were to be carried outside the railways, and would be in exposed conditions, and would be liable to damage either by accident or design, which would practically extinguish the whole supply from that particular company. He submitted that these were very cogent reasons why the City should not have its supply from that company. He wished to ask whether such a system could be confidently recommended as more than an experiment. They had it from Lord Crawford that they would run a main on each side of the street, which would be connected with one another in case of accident. The mains were to be rigid in form, and up to this time there had been no experience with such mains in this country. The whole of the present system of lighting from the Grosvenor Gallery had been by overhead wires, the insulation of which was much more perfect than that of underground wires. The tendency of the joints would be to get out of order considering the high tension—namely, 10,000 volts—at which it was intended to bring the electric current from Deptford to London. There had been evidence to the effect that transformers did not always do their work. It might be that the transformers of the London Electric Supply Corporation were better than those about which they had had evidence from America, while it had been stated that it was possible for a high tension to pass through a primary into a secondary converter. At the same time they had had evidence as to an accident that had happened to a gentleman at Pittsburg, America, with a voltage of 1,000, and it was quite clear that there would be considerable danger, if anything happened to the transformer, to the inhabitants of a house where such a system was adopted. If they were going to introduce an element of possible danger into the City, the Board of Trade must see that sufficient precautions were taken for the safety of the public in order to avoid any such contingency. The witnesses had pointed out the difficulty of connection there was between these rigid mains and the supply mains for a house. There was another matter in connection with the alternating system which he would like to emphasise, and that was that no motor for electrical energy had been yet discovered for it. The demand for motors had been constantly increasing in Berlin and New York, and possibly that might be the case in London, and one witness pointed out that the poorer class of people would be more likely to require electrical power rather than the light, and in neither of the provisional orders with which he was dealing was the supply of elect icity for any other purpose than lighting contemplated. In fact, in the agreement made by the Metropolitan Company with the Strand district there was an actual prohibition against the owner or occupier of any premises using the electricity supplied to him by the undertakers for any purpose other than lighting. Both orders were confined to electric lighting, and a great number of persons would prefer, if they were going to have a constant disturbance of the streets and a taking in and out of those cables, to have such a system as would supply motive power as well as light. Having dealt with the question of the want of storage in the system and the difficulty, as alleged by several of the witnesses, of properly insulating the mains, he said that competition in the City would be very inconvenient, he might almost say impossible. The streets were absolutely full, and it was impossible that more than one company could go into any particular district. He submitted that the local authority was the proper body to deal with the whole question. It was impossible to suppose that under the orders which he now opposed, and as they were now drawn, the City would be most unsatisfactorily lighted, and there were special circumstances connected with that portion of the metropolis which entitled the authorities to have some control over undertakers or companies of that description. He could quite understand that, as in the case of a railway or any other great public improvement, where there was an obstructive local authority who would not allow an undertaking to be carried through their dominions, it might be quite necessary that they should be disregarded and their wishes overlooked, but where they had to deal with a matter of this kind, when there was sufficient area in which both companies could exercise their ingenuity and enterprise, and increase their capital by multiplying their stations, he submitted that there was no occasion for interfering with the existing condition of things. In the present state of electric lighting, it was quite sufficient that those companies should have an area that would occupy them on a small scale. There would be no hardship either on the citizens of London or on the respective undertakings if they did not get their provisional orders, because the City of London would be quite safe in the hands of the Commissioners, who were trying to do the best they could for the future electric lighting of the City, because the provisional orders applied for, however beneficial for the companies concerned, were not conceived in the interests of the public at large. On these grounds he would ask the inspector to say in his report to the Board of Trade that there were special reasons for not including in those provisional orders the area of the City of London, and, secondly, that the form of electricity most adapted to it would be that the energy of which might be equally useful for electric lighting and motive power. He could assure the inspector that the Commissioners were not desirous in any way of putting a stop to the extension of electric lighting. On the contrary, they really wished to foster it; but they did not want to have such conditions imposed upon them as were contained in the provisional orders now applied for.

COMPANIES' MEETINGS.

INDO-EUROPEAN TELEGRAPH COMPANY, LIMITED.

The twenty-second ordinary general meeting of this Company was held on April 29 at Winchester House, Old Broad-street, Mr. J. H. Tritton presiding.

The **Chairman**, in moving the adoption of the report and the payment of a dividend for the half-year ended December 31 last of 17s. 6d. a share and a bonus of £1 a share (making with the interim dividend a distribution of 10 per cent. for the year), stated that the receipts for the year had been £110,327, or an increase of £6,036 over those of 1887, while the expenses had been £52,393, or £3,772 in excess of those of the previous year, the chief increase being £955 in agency expenses. From some points of view the traffic had been slightly discouraging, although there had been an increase on the whole. The Indian traffic had not brought them the results which they might have reasonably expected. So far from benefiting them, they had suffered from the reduction of the rate in 1886, the increase in the receipts which he had mentioned having been made up by Trans-Indian, Australasian, Persian, and South Russian messages. In 1880, the number of words per message was 18·83; it had gradually declined until in 1888 the number of words per message was only 12·66. This decline must, they supposed, be attributed to the greater perfection in what was called "coding," by which very much more was conveyed than the number of words employed. A review of all the circumstances led them to the conclusion that it was not so much the tariff which regulated the traffic as the activity or sluggishness of trade and commerce. Next year there would be a telegraphic conference in Paris, and they looked forward to it with feelings not altogether unmixed with anxiety. They never quite knew what might be said or done at these conferences, and the reductions in the tariff which had been made at them in the past had not proved very fruitful, for the European telegraphs, which were mostly in the hands of Governments, were worked at a loss. He believed he was right in saying that our own British telegraph service was worked at a loss, and the question arose how far the senders of messages, who forwarded them because they

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expected to make a profit out of the business they were conducting, were to be practically subsidised at the cost of the general community. The telegraph ought to pay for itself, and return a fair interest upon the capital and labour employed, just the same as any other business, whether its proprietors were States or private individuals. He concluded by referring with regret to the death of Colonel Holland, who was chairman of the Company for 20 years.

Mr. H. Weaver seconded the motion.

In answer to Mr. Jackson, the **Chairman** stated that at the time when they paid no dividends they could not start a sinking fund, as provided in their old articles of association. Latterly their circumstances had enabled them to put by money, until now they had more than 25 per cent. of their capital in reserve. They must look upon that partly as a fund against contingencies and partly in the light of a sinking fund. Their concessions would come to an end in rather less than 20 years. There was a clause both in the Russian and the Persian concessions under which the Company was bound to come to terms with those Governments, and they hoped and believed that that implied that the Governments would conceive themselves reasonably bound, in considering the terms, not to enter upon a course of confiscation. Mr. Jackson's remarks implied a desire that they should divide their reserve fund, but he thought it was always advisable to have a substantial amount in reserve against any contingency.

The motion was then unanimously adopted, and the retiring Directors and Auditors were subsequently re-elected.

NEW COMPANIES REGISTERED.

Brompton Electric Fittings Company, Limited.—Registered by Deacon, Gibson, and Medcalf, 4, St. Mary-axe, E.C., with a capital of £2,000 in £1 shares. Object: to supply public or private buildings with gas and electric light, and the fittings for the same. Registered without articles of association, and consequently the regulations of table A in the first schedule of the Companies' Act, 1862, apply.

CITY NOTES.

Great Northern Telegraph Company.—Messrs. C. J. Hambro and Son will pay the excess dividend on the Great Northern Telegraph Company's shares at the rate of 5s. per share on presentation of coupon No. 15 for the year 1888.

London Address.—Mr. Samuel Elliott, of Albert Moulding Mills, Newbury, the well-known manufacturer of wood casings for electro wires and cables, has taken London offices and showrooms at 63, Finsbury-pavement, E.C., opposite Moorgate Station. The firm's head office will still be at Newbury.

West India and Panama Telegraph Company.—The report for the half-year ended December 31 shows a balance of £22,892, out of which they have placed £1,000 to reserve, and propose the payment of 12s. per share on account of arrears of dividend on the first preference shares, the balance to be carried forward being £1,154.

Consolidated Telephone Construction and Maintenance Company.—The Directors of this Company recommend a final dividend at the rate of 7 per cent., less income tax, making, with the interim dividend, a distribution of 6 per cent. for the year ending March 31, after writing off £2,500 and carrying forward about £1,700.

West Coast of America Telegraph Company, Limited.—The report of this Company shows a gross income of £65,714 for the year ending December 31, against £57,893. After deducting debenture interest and all other charges, and providing for the dividends paid in July and January, the Directors recommend a further distribution of 2s. per share, payable on the 16th inst., making 6 per cent. for the year, to write off £500 from the value of the repairing steamer "Retriever" (thereby reducing her valuation in the books to £17,000), and to add £12,000 to the reserve fund, making the latter £39,000, leaving £480 to be carried forward.

Brazilian Submarine Telegraph Company.—The report of the Directors of this Company for the half-year ended December 31, 1888, to be submitted to the thirty-first ordinary general meeting states that the revenue for this period amounted to £133,708, and the working expenses to £23,553. After providing £12,880 for debenture interest and sinking funds and £1,985 for income tax, there remains a balance of £95,289; to this is added £4,539 brought forward from June 30 last, making a total of £99,828. First and second interim dividends amounting to £39,000 have been paid, and £40,000 transferred to the reserve fund, leaving the sum of £20,828 to be carried to the next account. Of this amount the Directors intend distributing £13,000 to the shareholders with, and in addition to, the quarterly dividend payable in June. In accordance with the provisions for repayment of the first issue of debentures, dated July 31, 1884, 145 bonds, representing £14,500, were drawn on the 12th ult. for payment at par on July 31 next. This, with the previous drawings, will make a total repayment of £65,500, leaving £84,500 of the first issue of debentures outstanding. The question of a reduced rate to Brazil has been under the consideration of the Board for some time, and it has been decided that reductions should be made in the tariff to Madeira, St. Vincent, and Pernambuco. It is anticipated the alteration will at the commencement affect the Company's revenue, but that the growth of traffic resulting from the reduced rates will greatly diminish the possible loss. Under an arrangement with the African Direct, the West African, and the Eastern and South African Telegraph Companies, additional traffic will be brought to this Company's lines between St. Vincent and Europe by the new cable now being laid to the Cape of Good Hope.

PROVISIONAL PATENTS, 1889.

APRIL 23.

6804. **Improvements in telephone transmitters.** William Robert Lake, 45, Southampton-buildings, London. (James Straton, Canada.) (Complete specification.)

APRIL 24.

6847. **Improvements in meters for registering the passage of electric currents.** George Edensor Dorman, The Hawthorns, Stafford, Staffordshire.

6865. **Improvements in secondary batteries.** George Eduard Heyl, 23, Southampton-buildings, London. (Complete specification.)

6867. **Improvements in "holders" for incandescent electric lamps.** Charles Richardson and George Hill, 74, Barrett-street, Brooks Bar, Manchester.

6869. **An improvement in the casings or covers of electric switches, cut-outs, and wall and ceiling fittings.** Joseph Slater Lewis, 53, Chancery-lane, London.

6875. **An improved construction and mounting of the spring armature and hammer for electric bells and other like electrical instruments.** James Charles Williamson, 34, Southampton-buildings, Chancery-lane, London.

APRIL 25.

6883. **Improvements in self-exciting alternate current dynamos, and self-starting synchronising motors.** Llewelyn B. Atkinson, 23, Andalus-road, Clapham.

6884. **Improvements in the means of obtaining motive power from alternating currents of electricity.** Llewelyn B. Atkinson, 23, Andalus-road, Clapham.

6885. **Improvements in apparatus for use with variable currents, and in the means of obtaining motive power from alternating currents of electricity.** Llewelyn B. Atkinson, 23, Andalus-road, Clapham.

6942. **Improvements in electrical accumulators or storage batteries.** Johannes Zacharias and Friedrich Marx, 4, South-street, Finsbury, London.

APRIL 26.

6954. **Improvements in meters for registering the passage of electric currents.** George Edensor Dorman, The Hawthorns, Stafford, Staffordshire.

6974. **Improvements in regulators for controlling the production and utilisation of electric currents.** George Edensor Dorman, The Hawthorns, Stafford, Staffordshire.

6981. **Improvements in annunciators in connection with electric, pneumatic, or other bells.** Jesse Kemsley, 57, New Broad-street.

7002. **Improvements in electric secondary or storage batteries.** Thomas Hammill Hicks, 45, Southampton-buildings, London. (Complete specification.)

7005. **Improvements in galvanic batteries.** Alexander Schanschieff, 24, Southampton-buildings, London.

APRIL 27.

7023. **Improvements in electric meters.** Robert Snowdon, 70, Market-street, Manchester.

7037. **Improvements in electricity meters.** James Blyth, 87, St. Vincent-street, Glasgow.

7038. **Improvements in electric-battery cells for lightening or for other purposes.** William Balch, 7, Field-view, London-fields.

SPECIFICATIONS PUBLISHED.

1888.

5098. **Electrical signalling for telephonic circuits.** Krieboom. 8d.

5162. **Electric generators.** Mordey. 8d.

5531. **Electric lighting, &c.** Statter. 8d.

7655. **Electric conductors, &c.** Crompton. 1s. 1d.

8099. **Electrical hoists.** Crompton and others. 8d.

17267. **Electric apparatus for propelling tramway-cars, &c.** Lake (Klames.) 8d.

1889.

3813. **Telephonic switching apparatus.** Bennett. 8d.

3870. **Electric motors, &c.** Lake (Lugo.) 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	18
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply ...	5	3¾
......	...	Swan United	3½	2¾
12 July	12/0	Telegraph Construction ...	12	42
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15½

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NOTES.

Madagascar.—The telegraphic lines in the Island of Madagascar has been destroyed by floods.

Electric Cabs.—Cabs driven by electric motors are mentioned as running at Washington and at Foree Bain in the States.

Paris Congress.—The congress at Paris during the Exhibition on the subject of electrical science will be held from August 24 to 31.

New Cable to Cape Town.—The new cable of the Eastern Telegraph Company to Cape Town along the West Coast is now completed.

Nantua.—M. Bertolux, who has fitted up central stations at Perigueux and St. Vierzon, France, has commenced the construction of a similar undertaking at Nantua.

Cost of Traction.—The Julien Company, of New York, speaking from experience, gives the cost of motive-power as 13s. for a car-day of 60 miles. This is 2·6d. per car-mile.

Brush Shares.—The debentures of the Anglo-American Brush Electric Light Corporation were over applied for, and the letters of allotment and of regret have been posted.

New Journal.—We have received the first number of the *Rapid Transit News*, a new journal published in Chicago for dealing exclusively with the ever-increasing tide of electric traction.

Mix and Genest.—The incorporation of this firm as a company in Berlin is now accomplished, with a capital of over 1,000,000 marks. A large extension of the factory is contemplated.

Students' Meetings.—A discussion on Prof. Forbes' paper on Central Stations took place last Friday. The next students' meeting will take place at the Sanctuary, S.W., on Friday, May 17.

Electric Traction in Paris.—It is announced at Paris that MM. Philippart Frères are about to renew their experiments of electric traction by accumulators upon one of the northern tramway lines.

Electric Light Casings.—The Gloucester Railway and Waggon Company, Gloucester, sends us a price list of casings for electric light wires, in which many neat and cheap mouldings are illustrated.

Metropolitan Railway.—We do not hear much about the experiments upon the underground railway. Probably both railway and traction people are waiting to see the result of the Southwark Subway Electric Railway.

Death of Col. McMurdo.—Col. McMurdo, of Berkeley-square, originally of Kentucky, died on Tuesday. He was concerned in Italian tramways, and was said to have recently acquired a new system of application of electricity to street cars.

Electric Verdant Indicator.—An electric invention is announced which rings a bell in the hotel office, and indicates the room number to call attention when any particularly verdant person blows the gas out instead of turning it off. Invented for Americans.

Cubzac.—The installation put down for lighting the town of Cubzac comprises two compound-wound Gramme machines of 135 volts and 90 amperes, serving 300 lamps of 10 to 16 c.p. Accumulators are kept in reserve. The concession, extending over 20 years, has been granted to M. Cun.

Melbourne.—Machinery for a complete electric tram-car system has recently been sent out by Messrs. Elwell-Parker for Melbourne. We also understand that they have in hand a set of plant for the same place for electric lighting, consisting of a central installation system for 6,000 16-c.p. lamps.

Buckingham Palace. — The electric lighting of Buckingham Palace has been extended, and the entrance hall, the marble hall, the grand staircase, the ballroom, the picture gallery, the promenade gallery, the dining-room, the blue drawing-room, and the saloon are all now lighted by it.

Spain.—On the 23rd of April the electric light was inaugurated in the town of Durango. At Albacete there are 864 lamps, and orders for 300 more have been received, but the Spaniards do not take up the light as quickly as expected, as the works were constructed on a scale contemplating a much greater demand.

Municipal Lighting in France.—Another instance of the municipal substitution of electric lighting for gas is that of the town of Lonhaus, where the town authorities have unanimously decided to substitute electricity for gas, from the 1st May, 1890, and have authorised the necessary arrangements to be made subject to their approval.

E.P.S. Company.—Mr. J. Irving Courtenay, managing director of the E.P.S. Company, writing to the *Times* to correct a serious misstatement attributed to the counsel for the London Electric Supply Corporation, mentions that the number of the shareholders is 511, and the authorised capital is £200,000, of which £149,450 is issued and fully paid up.

Novelties Exhibition.—An exhibition of novelties is to be opened on May 29, at the Central Hall, Holborn, to remain open till the end of July. The exhibits are to include all kinds of useful or scientific novelties. The hall, which is of 26,000ft. floor space, is a reconstruction of the old Holborn Theatre. The secretary of the exhibition is Mr. J. T. Alston, 15, Queen-street, E.C.

Gas-Heating Cylinders.—Messrs. Bryan, Donkin and Co. adopt the opposite method to water jacketting used in gas-engines, by gas jacketting steam-cylinders. By this means the cylinder is heated by gas, and the water which condenses on entrance is again evaporated and so increases the expansion. Messrs. Donkin have a model with glass cylinders on which the effect can be watched.

Electric Trams in Liverpool.—The City Council of Liverpool passed a resolution on May 1 that, subject to the sanction of the Board of Trade, the tramway companies would have their consent to run accumulator cars on the Liverpool lines. The Liverpool Tramway Company have sent down the wheels of one of their cars to be fitted with electric gearing by the Electric Traction Company.

Tramcars for Edinburgh.—It is thought that the tramcars of Edinburgh will be run by electricity before long. The hills are very steep here, and the probability

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is that two motors, one to each axle, would be used, the second motor only being used for the steep hills. This will make the getting up a hill a little more expensive, but the fair city will be better served with electricity than at present.

Belts.—To prevent the slipping of belts, a point to be guarded against when lighting direct by dynamos, a German journal advises washing the belts from time to time in warm water to remove clogs of dirt, and to brush them, afterwards lubricating them with equal parts of tallow and train oil. It is sufficient to lubricate them from the outside if desired. Lubrication keeps the belts supple ; mineral oil of any kind should not be used.

A New Excitant.—We learn that a new method has just been invented for chemically extracting mercury out of cinnabar, the ore of mercury. The bye products, which still contain a considerable amount of mercury, can be used as an excitant in a primary battery after the manner of the Schanschieff battery. The inventors are Messrs. Webber, Niblett, and Carver, who have jointly patented the process.

Paris Exhibition.—The Exposition Universelle was publicly opened last Monday and some 250,000 persons were admitted. The grounds and buildings are finished, but it will be probably some few weeks yet before every exhibit is complete. The Eiffel tower is finished and will be opened to ascent on May 15. The immense electric light on its summit, at an altitude of 1,100ft., is said to render print readable at a distance of seven miles.

Voltmeter Competition at Berlin.—The Berlin Electrical Society have instituted a competition for the construction of a voltmeter which shall be independent of variation of temperature or other disturbances; or, failing such an instrument, of an apparatus which shall control the working of the voltmeter, and indicate exactly the time during which the difference of potential has had a lower or higher value to its normal value. The premium is 1,000 marks, or £50.

Architects' Association.—This association has an annual festival, which this year took the form of the performance of a play at the Westminster Town Hall. There was some difficulty about the supply of light for footlights, and the aid of electricity was called in. Twelve accumulators with incandescent lamps were fitted up, with a resistance to turn the lights up and down, and the lighting proved very satisfactory. The work was carried out by the Acme Electric Works.

Admiralty "Voice Tubes."—There seems to be considerable activity in the Admiralty Department in electric bells and indicators, or, as they are known in official parlance, "voice tubes." The Acme Works have supplied some 400 of these instruments, and other firms we have heard of are making or tendering for the same kind of apparatus. The voice tubes consist of an electric bell with three indicators to Admiralty pattern, for use in signalling orders to the engineers.

Magnetic Ore Separator.—Edison is now reported to be at work on a magnetic ore separator for use with crushed ores, diverted, after crushing into different shoots, by strong magnets. A similar apparatus was shown in the Inventions Exhibition for sorting rubbish from nails, etc., but we are not aware whether the invention has been applied to much practical use in England. A company is being formed to work Edison's separator, and machinery is being put up at a cost of 35,000dols.

Telegraphs as Investments.—The *Financial News*, specially commenting on the good prospects of the Great Northern Telegraph Company of Copenhagen, says: "Telegraphs are still an out-of-the-way market, frequented only by investors with special information. The average broker does not take much trouble to bring it under the notice of his clients, and the opportunities it affords for getting a good return with fair security are not so freely taken advantage of as they might be."

Series v. Accumulators.—An amusing instance of the interchangeability of electric tramcar systems occurred in a discussion the other day. A certain noble lord interested in series was talking to another noble lord who swears by storage cars. What would you do, suggested the latter, in the case of a single car or two wanting to be run for workmen at 5.30 in the morning, and not another required till seven o'clock: would you keep your series apparatus running for these? Oh, no, said the series man; that difficulty would be easily got over: I should use storage cars!

New Paris Theatre.—An international theatre will be erected at the foot of the Eiffel Tower for the purpose of performances being given therein by the people of all nations. The theatre, which has been contracted to be opened on the 10th June, will hold 2,000 persons, and will have attached to it a smaller theatre for about 300 for experimental purposes. The whole building will be lit by the electric light. Mr. Seymour Wade, the Theatre, and of Blomfield House, London-wall, E.C., has the arrangements in hand.

Electric Date Stamps.—The various telegraph companies are appreciating the virtues of the electric date and time stamp, and are, we hear, ordering in considerable quantities. The Post Office are open to adopt them, if the usual progressive number can be stamped at the same time. Mr. Randall is at work adapting his instrument to this purpose. They are also being used for checking-in workmen, and several other purposes. The Helsby Manufacturing Company have made one lot of them, and we understand that the Acme Electric Works have recently contracted for a number.

American Engineers in London.—At the last meeting of the Court of Common Council, the Lord Mayor laid before the Court a letter from Sir G. B. Bruce, the president of the Institution of Civil Engineers, applying for the use of the Guidhall for the purposes of an international banquet on Thursday, 13th June, to be given by the institution on the occasion of the arrival in this country of the representatives of the leading American societies of civil, mining, mechânical, and electrical engineers *en route* to the Paris Exhibition. The request was unanimously complied with, and the City Lands Committee were directed to make the necessary arrangements.

Electric Light in Printing Offices.—We are glad to see that the smaller printing offices are taking up the electric light. We heard some little while ago that the *West Middlesex Standard*, printed at the Broadway, Ealing, was lighted by electric light, and being in the district this week we looked in and found one of the neatest printing and composing rooms to be desired. The printing presses are run with a 4 h.p. Otto gas-engine, indicating up to 7 h.p., and this also drives a dynamo, Maxim-Weston type,

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for lighting the premises. There are 47 16-c.p. lamps, and eight 50-c.p. lamps, which are run at the same time as the machinery, with very satisfactory results.

Health Congress.—The Health Congress opened last week at Hastings with a sitting of the municipal sanitation section. Major-General Webber, C.B., president of that section, delivered an important address on "Lighting of Towns in Relation to Health," warmly advocating the superiority of the electric light, which system of lighting, he argued, must become general, and be produced nearly as cheaply as gas in the near future. He specially commended the light on sanitary grounds. Prof. Ayrton advocated gas for heating, and the electric current for lighting and ventilation, observing that if gas were generally used for heatng it would do away with the dark clouds now hanging over great cities.

Australian Enterprise.—Miss Cornwell, known as "Princess Midas," the rich Australian lady who was to have bought the Schanschieff battery patents, is now in London, and has taken offices at 32, Queen Victoria-street, City, bent on projects to "advance Australia." We don't know how far electric lighting, traction, and mining come within her province, but as she has more than once evinced interest in things electrical, those interested in such plant suitable for Australia might be glad to be able to communicate with Miss Cornwell while in England, as it is well known she has various schemes on hand for the general benefit of her native land, and the pockets of various shareholders.

Immisch Dynamos.—Some very neat and well-engineered dynamos for lighting purposes are being turned out at Messrs. Immisch's works, under the superintendence of Mr. Albion T. Snell. We lately saw some of these; one for 12,000 watts, standing only 20in. high, looks a thoroughly good piece of work, from a mechanical point of view, and very compact for the output. A large machine for 50,000 at 400 revolutions, or giving up to 100,000, if necessary, was in progress on the lathe. We understand that the works are very busy, more orders being in hand at present than before at any corresponding period, a large amount being for motors for mining purposes, both for English mines, and for the Colonies, and abroad.

Electricity in Literature.—We learn that in the June number of *Scribner's Magazine* there will be begun a series of popular articles on the Practical Applications of Electricity. Among the subjects to be treated, the following are now arranged for: "The Principles of Electricity," by Prof. Cyrus F. Brackett; "Electricity in Modern Telegraphy," by Charles L. Buckingham; "Electricity in the Household," by A. E. Kennelly; "Electricity, and its Relations to the Human Body," by Dr. M. Allen Starr; "Electricity in Warfare," by Lieutenant W. S. Hughes, U.S.N., and Lieutenant John Millis, U.S.A.; and "Electricity in Large Industries," by a gentleman whose name is yet to be announced. The series will be elaborately illustrated by the best American artists and engravers.

Copper Refining.—Depositing dynamos have recently been supplied by Elwell-Parker to the extent of 1,000 h.p. for copper refining at Widnes. The process is far cheaper than the ordinary method, costing only about 10s. per ton. The method employed generally consists in first buying oxides as rich in silver and gold as possible; casting these in thick plates of 1in. to 2in. thick, roughly cast in a tray successively one on top of the other, with a little powder between, and then split up into plates. These are used as anodes in a depositing bath of sulphate of copper, the pure copper depositing, and the impurities, together with the precious metals, settling as a kind of sludge. The plates are usually some three feet by two, and at the works in question 56 tons of pure copper is deposited per week by these dynamos.

Electric Tramcars and Locomotives.—The success of the trials of the electric locomotives, first run publicly by Messrs. Elwell-Parker on November 7th in Birmingham, and described in this journal, has led to very many enquiries and some very substantial orders. This company have now in hand orders for some eight thousand pounds' worth of storage cars and electric locomotives. A large part of these are, of course, electric locomotives for the Birmingham tramways; but a number of other tram lines are having cars fitted up, many of them being self-contained storage cars. Another use to which electric locomotives are being put is that of moving stores, etc., in the fortifications, and an order from Government for a locomotive for this purpose for Plymouth has been received. The motor is some 8 or 10 h.p., and will be used for transport of all kinds of stores; the great advantage being the absence of any emission of smoke or steam.

Southampton.—The borough surveyor of Southampton, Mr. W. B. G. Bennett, read a paper the other day at the meeting of the Association of Municipal Engineers held at Southampton, in which he referred to the experiment which he had been carrying out to utilise the waste heat from the refuse destructor, in order to produce electricity. At the present time the works are lighted with two arcs of 3,000 c.p. each and 12 incandescents, in addition to which four streets in the vicinity are frequently lighted for the information of the Corporation. So successful have been the results that the Corporation unanimously resolved to extend the installation to the Municipal Offices, the Hartley Institution, the Town Hall, etc. For this purpose accumulators will be used and charged by a cable. Mr. Bennett also referred to the experiment of Mr. Webster for the electrical treatment of sewage, and stated that when the system was perfect nothing would be easier than for them to try it.

Inductive Intoxication.—While Prof. Lodge has been showing the unexpected inductive effect of real and artificial lightning, the *Popular Scientific Monthly* points out that "Jersey Lightning," otherwise strong drink, sometimes exerts what may be termed inductive action upon men who have had the ground prepared in times gone by. Various cases are cited in which military men, or other old stagers now reformed from drinking habits, when in company with other boon companions at dinner, though not themselves drinking anything stronger than coffee or lemonade, have yet manifested distinct symptoms of drunkenness after some little time in company with their hilarious companions. One man, after twelve years sobriety, on a military excursion with a drinking company, became thoroughly intoxicated by induction, though drinking nothing but water, an event which was the subject of much comment and loss socially to him, though all with him knew he had touched no alcohol.

Lecture on Transmission of Energy.—At the Ipswich Scientific Society last week, Mr. W. B. Sisling, of Messrs. Laurence, Paris, and Scott, Limited, delivered a lecture on the "Transmission of Energy by Electricity." The lecturer described the various systems of transmitting

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energy, and used as an illustration a certain diamond mine, whose nearest source of energy was a coal mine, separated from the diamond mine by 200 miles of waste country. Mr. Sisling pointed out the enormous expense of building a railway to convey the coal, but by using electricity the current could be sent through wires to work the diamond mine. This was exemplified by models on a small scale. The hall was lighted by incandescent lamps, the current for these and for driving the motors—shown in motion—being supplied from the central station of Messrs. Laurence, Paris, and Scott. Several questions were asked of the lecturer, and a hearty vote of thanks were accorded to him at the conclusion of the meeting.

Tramcar Etiquette.—With perfection in the power supplying the tramway services by the introduction of electric traction, tramcar directors might well also look to perfection in civility of the attendants. The German conductors seem models in this respect from the remarks in a recent article. "The German tramcar conductor is polite. When a passenger boards or leaves the car the conductor touches his hat and says 'Good day.' When he collects a fare he attracts the passenger's attention by saying 'please.' The German conductor is phenomenally patient with foreigners, and few have seen him ruffled in the long incidental explanations and arguments. He smiles good-naturedly at the babies when collecting the fares, and holds a guarding hand when the mother alights. His collar and cuffs are clean. His uniform is never ragged or greasy, nor are his boots unblacked. In fact, a German tramcar conductor is generally so mannerly, clean, and well dressed that he is a bit of a prince among his class of society."

Sprague Motors.—It is stated that the factory of the Sprague Electric Railway and Motor Company is overcrowded with orders for motors, both for stationary and railway work. The large number of railroad companies which have ordered the new 30 h.p. motor car equipment and improved Sprague motors, would have been sufficient alone to have kept the business of the Sprague Company devoted exclusively to that branch of the electric power field. But the attention of the Sprague Company has not been devoted entirely to this class of work. They have recently received a number of large orders for stationary motors, including one to operate a mill in Nebraska by electricity, using more than 100 h.p. of motors, with the generating station more than three miles away. In addition to this order, they have received a number of others for less individual capacity, but making a very large aggregate Several other mills have ordered complete electrical equipments, and a large number of orders for stationary motors have been sent in from all directions.

Sugar Refining by Electricity.—"Yet another, oh, my Friend!" No, not quite another, as the following method is expressly stated to have "nothing in common with that of Prof. Friend," of New York and—, well, say sorrowful memory. It has been dug out of the depths of the French Patent Office, where it was recently deposited by M. Bauder, and is founded upon a production of ozone by the combined action of steam and electricity. According to the description given of this method, the raw sugar is placed in a machine having a centrifugal action, and constructed with an hermetically sealed cover, through which the conducting wires are passed at short distances from each other. Steam is introduced, and when the sugar is sufficiently moistened, sparks are allowed to pass between the wires. The ozone liberated is said to refine the sugar. The syrup is separated by centrifugal force, and can be mixed with other raw sugar and again submitted to the same treatment. Might be termed refining by "faradisation." Mr. Wimshurst may be interested to hear this; but, we should suppose, no more shareholders.

Export Catalogue.—We have received a copy of the "Annual Export Catalogue of Machinery and Hardware" from the Machinery and Hardware Company, Limited, 147, Queen Victoria-street. It is simply a bound book of advertisements and price lists of specialities for the colonies and abroad, and includes the names of very many important English firms, and has brought satisfactory business from the most remote places abroad. The catalogue is published annually, and has a guaranteed free circulation of 10,000 copies. These are distributed throughout the home markets, to merchants, shippers, Chambers of Commerce, foreign Consuls and Ministers, and public works, etc.; but the bulk of them go to selected buyers in India, the colonies, and the continent generally. The present edition is sent to the United Kingdom, India, Australia, New Zealand, Canada, Germany, France, Italy, Austria, Spain, Russia, Norway, Sweden, Portugal, Greece, Denmark, Turkey, Egypt, Roumania, China, Japan, South American States, the Cape, Fiji, Tasmania, Morocco, Malta, Cyprus, etc. One edition is in English, one in Spanish, and one in German, and it should be useful to some of our readers who are sending goods abroad.

Aerial Wires in New York.—The war against overhead wires in New York has been carried forward through thick and thin—through telegraph and through electric light wires, that is. The *Scientific American* gives a graphic note upon the subject. "An attempt," it says, "on the part of the Western Union Telegraph Co., to obtain an injunction in the Federal courts having failed, the city authorities put a large force of men at work to cut and remove the wires and lower the poles. Unfortunately, the work has been marred by casualties, one instant death and several injuries resulting. One lineman, who had climbed a pole, narrowly escaped with his life, as the rotten wood gave way, and the pole, unbraced by the usual telegraph lines, fell. It fortunately struck against a building, so that the operative was afforded a chance of escape, which he was quick to profit by. This accident showed that the poles were a distinct source of danger as they became more and more decayed. A very impressive feature of the operations is the comparative darkness to which the city in these parts is relegated at night. The gas lamps are quite unable to supply sufficient light for the people, who have now been accustomed to electric illumination. It is to be hoped that the electric light companies will make every effort to start their lamps anew, and give the many centennial visitors a good illustration of subway electric supply and illumination."

Medical Electricity.—The "British Association of Medical Electricians," as Mr. C. B. Harness has named his society, has issued the first number of a *Journal*. The receipt of this paper led us to pay a visit to Mr. Harness' rooms to see what really there was to be seen, and whatever may be our strong opinions as to his electropathic belt and magnetic hairbrush, we must in justice say there can only be one opinion upon one portion of his apparatus—that of the Zander Institute of Swedish mechanical exercise machines. These are a marvel of ingenuity, both from an engineer's point of view, for the multitude of complicated

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motions brought about, as well as from that of their adaptation to anatomy for the purpose of mechanically exercising limbs, and for treatment by massage, and no expense has evidently been spared in fitting up this department. Now, we can only say, after inspecting these massage machines, that if Mr. Harness would only give the order to fit up electrical apparatus in the same perfect and thorough manner for research by delicate electric testing of the human body, by someone really competent and on scientific grounds, he might yet do more good in medical electricity than the harm ascribed to him by the accumulation of lucre through the sale of high-priced warm flannel "electropathic" belts. Mr. Harness' views for the future appear to be enchantingly comprehensive. He will attempt to inaugurate a "new faculty" for the prosecution of the practice of medical electricity. He would found a free electropathic hospital, and join in a compact hitherto unachieved—by the help of his French doctors from the Salpêtrière—between anatomical science and electricity. Mr. Harness has now a fine Wimshurst machine, and gets very good sparks from it. He has also these fine massage machines, and some very elaborate and wonderful anatomical diagrams. Whenever he cares to spend his money by developing his electrical apparatus to any similar extent, we would again visit his palatial premises, and have, possibly, something to say on the utility or the reverse of his apparatus from an electrical point of view.

Electric Launches up the River.—Summer came in with a rush with the month of May this year, and boating was begun with great fervour last Sunday all the way up the River Thames. There is great talk this year amongst boating men of the introduction of electrical launches, and we hear that Messrs. Immisch have been far from idle—in fact, very busy in fitting up charging stations along the upper reaches. We believe there is to be one permanent charging station at Platt's Island, and three floating stations at points extending up to Maidenhead, with others to follow. It is open to conjecture how far the electric launch business will succeed, and we shall be extremely interested in the result of Messrs. Immisch's venture. Steam launches are a success because coal is cheap, and coal can be bought everywhere; whereas an electric launch cannot at present go more than a day's journey from the source of its power. Therefore, it is, that charging stations are a necessity. But independently of this, there is quite a limit to their use, though how far it may extend we cannot yet tell. But the bulk of boating men go boating, not for relaxation only, but relaxation of mind combined with exercise of body, and the fact that the work is done for you will by no means induce the bulk of boating people to go in for electric launches. The great advantages, however, of these over steam launches in the matter of smell and vibration, independently of the novelty of the thing, will doubtless cause large numbers of the present "launchers" to patronise electricity. One thing we should like to impress upon Messrs. Immisch and their engineers, who are engineers first, and boating men only as a mere detail. It is this, that before all things the greatest care should be taken not to disfigure the lovely banks of the Thames by uncouth engineering work, or blackened and smoke-belching machinery; nor to cut down trees or bushes, or otherwise destroy the beauty that is dear to the pleasure-seekers up the Thames. If the slightest cause of this kind is given for complaint, electric launches will come in for unthought-of opprobrium, for it will save nothing to make river locomotion easier, if the river itself is not worth going to see by reason of charging stations. However, "a word to the wise is enough," and we shall hope to have an opportunity soon this year of practically testing the delight of an electric day "up the river."

Royal Society Conversazione.—A most interesting meeting with exhibition of various apparatus took place at the Royal Society conversazione on Wednesday evening. Mr. C. V. Boys showed an experiment illustrating the insulating power of his quartz threads. Gold leaves were attached to a quartz rod drawn out fine for about an inch. The atmosphere was kept moist by a dish of water. A glass insulating stem would allow all the charge to escape in a second or two, but with the quartz very little change is observed for four or five hours. The quartz may even be dipped in water without apparently altering its insulation. Mr. R. A. Hadfield had a magnificent exhibit illustrating the non-magnetic properties of manganese steel. A number of strong horseshoe magnets were arranged over cups filled with filings from steel containing various percentages of manganese. The filings rose in a bunch in the centre of some of the cups, but gradually diminished until no effect was observed in the specimens containing over about 12 per cent. manganese. Capt. Holden exhibited a chronograph for measuring speed of projectiles, in which the shot, passing the screen, breaks an electric circuit, which holds up a copper tube screwed to an iron head. As this drops, the second screen lets a knife-edge fall in a similar manner, making a notch, and the length along the tube is a measure of the velocity. Capt. Holden also exhibited his hydrometer for secondary batteries, giving a range of about 7in. for difference in specific gravity of from 1·160 to 1·200. Pitkin and Niblett's firedamp meter, which we describe more in detail elsewhere, attracted a great deal of attention. The principle is simply that the occlusion of gas or explosive mixture on a suitably prepared bulb increases the temperature of one arm of a thermometer. Mr. Pitkin also exhibited his neat little pocket lamp of 1 c.p., weighing about 1¾lb. Mr. J. W. Swan had sent an interesting method of showing the effect of the earth's magnetism—a motor with Gramme ring, but without field-magnets other than N. and S. magnetic poles of the earth. The motor revolved with a current of ½ ampere in the armature. Mr. Shelford Bidwell showed the effect of light in magnetising iron. A bar after magnetisation by a current is partially demagnetised by a reversed current. When light is let fall upon the bar, it instantly deflects the magnetometer needle. Dr. Gore exhibited his voltaic balance for detecting very minute quantities in chemical analysis. Prof. W. N. Hartley showed numerous films on mica of various metals and metallic oxides in prismatic colours deposited by the electric spark. Mr. Muybridge showed his automatic electro-photographs of moving animals by the electric lantern, illustrating the various phases of locomotion. Mr. Eric Bruce attracted a great deal of attention by an "electro-graphoscope" showing the illusion obtained by the persistence of vision. A lantern was prepared with the figure of an angel and directed into space, and, of course, nothing could be seen. The electro-graphoscope consisted of a white lath of wood an inch wide and about 2ft. 6in. long, made to revolve very rapidly by an electromotor. When in motion, the effect is an almost invisible haze, but when the revolving lath is placed in the rays from the lantern the effect was as of a solid angel in relief suspended in mid-air, due to the persistence on the vision of minute fractions of the lantern image.

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FIREDAMP METER.

At the Royal Society's Conversazione on Wednesday a new form of firedamp meter was exhibited by Messrs. Pitkin and Niblett, which promises to be very useful in conjunction with electric lighting in mining operations.

In its simplest form this instrument consists of two ordinary cylindrical bulbed thermometers graduated to the ordinary Fahrenheit scale, and mounted on a polished boxwood block. For their protection the thermometer stems are recessed into the wood frame. Slots going right through are made to receive the bulbs. These apertures are covered on both sides with fine wire gauze, held firmly on by brass frames. By this arrangement the bulbs are protected against dirt and accidental damage. The left-hand tube is the gas indicator. The right-hand stem merely serves as a temperature register of the surrounding air. When the instrument is placed in a mixture of certain explosive gases, such as ordinary coal-gas and air, or firedamp and air, an immediate rise in the mercury in the indicator stem is observed. This gradual rising goes on until it reaches a maximum, when, unless a continuous current of the mixed gases is caused to flow through the instrument, the mercury column will come to rest and then slowly subside. The percentage of the explosive gas in the mixture is estimated by taking the difference in degrees in the readings of the two scales when the indicator mercury is at its maximum. In one of the instruments tested a difference in the readings of

2 deg.	= 1	per cent.	of active gas
6 "	= 2	"	"
13 "	= 3	"	"
23 "	= 4	"	"
36 "	= 5	"	"
53 "	= 6	"	"
85 "	= 7	"	"

These readings point to a fairly definite law, except in the case of the last reading, when we must assume an error of observation, or some other error. From the other readings it will be seen that the second order of differences is constant.

On the scales one division represents two deg. F. Of course, each instrument will have to be calibrated, either from a standard or from a known mixture of gas.

In working out the above, that peculiar property of certain rare metals is made use of, which, when in a very finely-divided state, occlude and facilitate the chemical combination of oxygen and hydrogen, and also in some instances of oxygen and such unstable compounds of hydrogen, such as of coal gas and firedamp. Of these metals it is found that paladium, platinum, and iridium are the most energetic. Platinum-black or spongy platinum is perhaps the most readily obtained, and answers the purpose admirably, as in this instrument, if a bulb is covered with a thin layer of platinum-black, and is then subjected to the influence of any mixture of oxygen and hydrogen, chemical combination of the two gases takes place within the pores of the spongy metal. During the combination a considerable amount of heat is given out. This causes the rapid rise observable in the mercury column.

As the indicator answers well in mixtures of ordinary coal-gas and air, we think it might be of use in gas works, etc., where it could be used to detect leakages in pipe retorts and holders.

In an ordinary way, the instrument may be readily tested by holding it over a gas-burner and allowing the gas to impinge upon the wire gauze, or better still, a little gas may be collected in a glass jug or jar by upward displacement, and then inserting the meter so as to bring its bulbs within the influence of the gaseous mixture.

Various forms of the meter can be made—some of which we shall illustrate in our next issue. It can be easily applied to the electric miners' lamp, and, besides giving a visual indication by the rise of mercury or the motion of a pointer, can be made to give an aural one by means of a bell, the mercury or pointer making electrical contact to the bell when the mixture of gases approaches the dangerous state. Altogether, the instrument is very interesting, and promises to be of great practical utility.

THE CARSTAIRS ELECTRIC RAILWAY.

Messrs. Anderson and Munro, of Glasgow, are now putting the finishing touches to this, the first electric railway in Scotland. It extends from Carstairs House, the residence of Mr. Joseph Monteith, to Carstairs Junction on the Caledonian Railway System. It has been constructed chiefly as a means of rapid and always ready communication between the station and Mansion House; but it has branches and sidings, so that it may serve for local farm and estate traffic. The line runs for a mile and a quarter through some of the most beautiful scenery on the Carstairs estate, and with its narrow (30in.) gauge, flanked on either side by rows of neat ivory-coloured insulators, adds to the interest of the scene, while, owing to the absence of all smoke and dirt and noise, it will not in the least mar the charm of its surroundings. The conductors are rectangular rods of very pure iron, arranged the positive on the one side, the negative on the other, about a foot outside of the rails. The conductors are attached to specially designed insulators by an elastic steel fastening, which allows of no side shake, but permits the rods to expand freely, and which can be easily replaced should any insulator get broken. The insulators are in turn supported on iron rods, rising some 10in. from the sleepers to which they are attached. A handsome electric carriage is being constructed, and during the trial runs a speed of 35 miles an hour was attained, and could have been easily surpassed. At all speeds the motion was exceedingly smooth and pleasant.

The source of power is a waterfall three miles distant. When the car is at the station end, therefore, the current traverses eight and a half miles of conductor. As the Mansion House had to be lit throughout by the same current, and as it was necessary to keep the potential difference under 250 volts at railway to obviate danger from shock, and the size of conductor small on account of its length, it will be seen that a very pretty problem was presented for solution. Fortunately, there was ample water-power to waste, so a series-wound dynamo of Goolden type, giving 400 volts and about 40 amperes, was placed beside the turbine, and current was carried over the three miles to the Mansion House along four bare copper wires run on fluid insulators. "Earth" is nowhere used, the circuit being metallic and insulated throughout with a view to secure higher insulation, less danger of shock at the house and railway, a double chance against snow, and a circuit of constant resistance. At the Mansion House there is placed a battery of 100 E.P.S. cells, which are charged all in series. This battery when discharging has the house wires so joined up that one half supplies one section of the house and the other half another section, although, when lighting lamps only, it can be transformed into one battery of 100 volts, the two halves being then in parallel. The cars can be run from the cells alone, from the dynamo alone, or from both coupled. The varying demands for current produce large variations of field-magnet strength, and consequently of E.M.F. at the terminals of the series dynamo, but, on the other hand, the large line resistance causes fluctuations in the opposite direction in the amount of loss in the line. This loss varies from 0 up to 150 volts. The dynamo characteristic and the line resistance have been so adjusted that, within a working range of current strength, the potential difference at the house switchboard is approximately 250 volts. An automatic appliance keeps the current flowing always within the desired range, so that even if all load is thrown off there is not more than 250 volts on the railway conductors, nor are the field-magnets demagnetised. At present an attendant resident in the vicinity starts and stops the dynamo on receipt of signal, but it is the intention to put in a small motor to put off and on the water supply. A pair of little brushes will be placed midway on either side between the chief collecting brushes, and these little brushes coupled together are joined to the signalling wire after passing through the armature of little motor. The electromagnets of the motor are a shunt on the main wires. By joining the accumulator end of the signalling wire to the positive or negative wire respectively, a current flows through the small motor armature in one or the other

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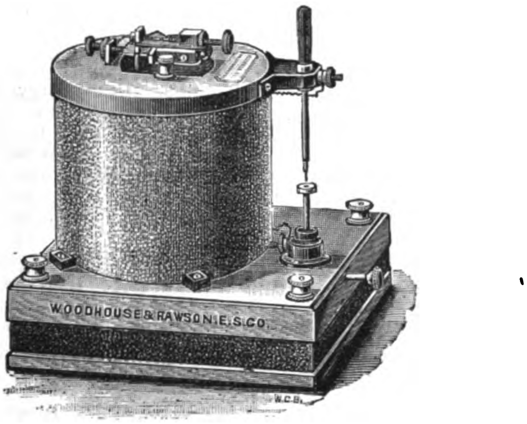
direction. Thus, by putting a switch at the house to right or to left, the water can be put off or on at the turbine three miles distant. We hope to give drawing of the car when it is completed, showing details of its mechanism. The whole system has been designed by Mr. John M. M. Munro (of Anderson and Munro, the contractors for the work), and carried out under his superintendence. Mr. Monteith, who is himself a skilful engineer, has taken a close personal interest in the construction of this railway, and with Mr. David Hunter, of Lanark, has materially assisted the progress and perfecting of the work.

PYKE AND BARNETT'S FLAME SPARK COIL, WITH CONTINUOUS ACTION RAPID BREAK.

Our readers will remember that, some time ago, we gave a short description of the above apparatus, and we now have pleasure in illustrating the commercial model of the invention at present made and stocked by Messrs. Woodhouse and Rawson. It will be seen from the woodcut that the design has been rendered more compact, and that the moving parts of the break (which is in the recessed centre of the coil) project above the topboard for ready adjustment.

The break is quite a new departure, and from its certainty of action, forms, perhaps, the most valuable improvement in these coils.



The principle of its action is as follows: a hammer, mounted on a short thick spring, is very rapidly and vigorously vibrated by means of an electromagnet included in a shunt circuit, and the main or coil contacts are so arranged that (one of them being mounted on a spring) on the recoil of the vibrating hammer it strikes against the movable main contact, and causes a slight and instant separation. The whole of the parts are arranged for ready and rapid adjustment, and the flat contacts are arranged on screws, which are readily removable for replatinising. The arrangement of the dischargers is also very neat and not so liable to damage as the old style. The size of the coil, No. 1, is 5in. diameter by $4\frac{5}{8}$in. high. Another size of this convenient high-tension current generator will be shortly procurable.

SECONDARY BATTERIES.*

BY WILLIAM HENRY PREECE, F.R.S.

Secondary batteries are often called accumulators and storage batteries, and the general impression is that they accumulate or store that which is called "electricity." What is accumulated or stored is, however, energy in its chemical form. A *secondary* battery is really a battery pure and simple, but it differs from a *primary* battery in this that the chemical character of the conductors or plates, and the electrolyte in which they are immersed, has been excited by an electric current which has passed through them continuously for some time; while in a primary battery the chemical affinities exist in the materials of which the cell is composed. In the language of the distinguished American, Judge Coxe, "A secondary battery is one which gives no electricity of itself, but is active only when rendered so by a current from an independent source."

Secondary batteries have become an essential feature of every properly equipped isolated electric light installation, not only for the regulation of electric currents, and the maintenance of uniform E.M.F., but to give a store of energy to draw upon at night, and when any accident or failure occurs. They are also employed for the distribution of electrical energy from central stations. They are used for ship and for train lighting, and they seemed destined to solve the important question of economical traction on our tramways. They are much used in telegraphy. They have passed through a very severe ordeal of seven years' practical development in the face of determined opposition, and in spite of the prejudice resulting from disastrous commercial speculations, and from the non-fulfilment of over-sanguine hopes and hasty utilitarian anticipations.

The father of lead secondary batteries, in a scientific sense, is the eminent French electrician, Gaston Planté, but the final stroke that made the apparatus a real practical instrument was the discovery of Faure, who showed that the application of oxides of lead, in the form of a paste or cement on the surface of the lead supports, so hastened the process of formation of the plates that the battery was made a commercial and valuable instrument. Sellon, Volkmar, Swan, Julien, Parker, King, Drake, and Gorham have added so much to the mechanical details, and have done so much to remedy defects and remove faults of construction, that all we want now is to crystalise into practical language the teachings of experience.

My house has been lighted by these batteries since March, 1884, now five years ago. I commenced with 17 Planté cells, manufactured by Elwell, Parker, and Co., of Wolverhampton, charged by currents from a dynamo driven by a 2 h.p. gas-engine, but after two years of experimenting I selected 26 cells of the 15 L E.P.S. type, with which form of cells I am now working. Their value can be illustrated by the following fact: On March 30 my gas-engine broke down. I quite forgot to give notice to the makers to send down men to repair it until six days had elapsed. It took five more days to repair the engine, so that for eleven days I had not been able to recharge the cells; but during all these days the light never failed, and we were not in any way inconvenienced. The useful capacity of my cells is 330 ampere-hours, and my nightly consumption is now about 30 ampere-hours. This was a very good test of the efficiency of the cells, for I obtained from them nearly all the energy they could usefully give. Only two cells were really exhausted during this time, but as I had two spare cells to replace them, their exhaustion did not cause me any inconvenience. The E.M.F. fell to 1·8 per cell, and the light in consequence was not so brilliant as usual. A good practical test of the efficiency of a battery like this is better than any isolated tests on single cells.

The illumination of this hall (Society of Arts) is regulated by 58 E.P.S. cells, of 13 L type, an obsolete, which are used, when the hall is not open, to light the secretary's and the public offices. They have been at work there since January, 1885, and have given no trouble and very great satisfaction.

Types of Cell.

There are several kinds and types of cells in use at the present day, but the principal ones supplied in England are by the Electrical Power Storage Company and by Elwell-Parker Company, Limited. The E.P.S. cells are of several patterns: "L."—Stationary cells used for electric lighting motive-power, and general purposes. "T."—Portable cells used for tramcar and launch propulsion. "C."—Portable cells used for railway carriage lighting.

Of the "L" pattern the following are the sizes issued:

No. of plates.	Weight.	Maximum rate of discharge (amperes).	No. of 10-candle power lamps (26 cells).	Capacity (ampere-hours).
	lb.			
7 L	68	13	21	130
11 L	101	22	36	220
15 L	128	30	50	330
23 L	211	47	76	500
31 L	265	64	100	660

There are always one more negative plate than positive.

E.P.S. Type, 1888.

The plates of each cell are divided into the positive and the negative, in each case a pure lead grid being cast for retaining the paste-oxide $8\frac{1}{4}$ by $9\frac{1}{4}$ by $\frac{1}{16}$ thick, and weighing 5lb. The perforations or openings of the positive plate are filled with minium, while those of the negative plates are filled with litharge. The plates so prepared are then subjected to powerful currents for several hours, when the litharge (PbO) is reduced to spongy lead (Pb), and the minium and red lead (Pb_3O_4) become lead peroxide (PbO_2). There is thus economy in reducing the lower oxide and in peroxidising the higher one. Many attempts have been made to manufacture the grids of inoxidisable alloys, such as an alloy of antimony and lead, to which mercury is sometimes added, but so far nothing seems to be superior to the pure lead itself. The principal defect has been that of buckling or deforming, and this is supposed to be due to irregular oxidisation, but no clear explanation has yet been given of the remarkable way in which lead plates curl and curve under the influence of electrolysis. Plates do not buckle when they are properly treated. It is the rough handling of cells—calling upon them to do more than they were designed for—neglecting to maintain the level of the liquid and its density that principally lead to deformation, disintegration, and also short-circuiting from the paste falling out in

* Paper read before the Society of Arts, May 1. This subject has been before the society on two occasions. In 1881 (vol. xxx., p. 30) Prof. Silvanus Thompson read a paper on the "Storage of Electricity"; and in 1883 (vol. xxxi., pp. 1,025, 1,038), Prof. Oliver Lodge, F.R.S., gave two lectures on "Secondary Batteries."

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lugs and resting across the plates. The plates are now fixed ⅜ths of an inch apart, a sufficient distance to allow any pellet that may fall out to drop harmlessly to the bottom of the cell. This distance can be increased with advantage.

The pellets of paste are now made considerably smaller than was the case at first, and this has been done to hasten the period of formation, and to render the whole of the pellet active, which was not always the case with the larger pellet, for the centres were often found unformed, and therefore idle.

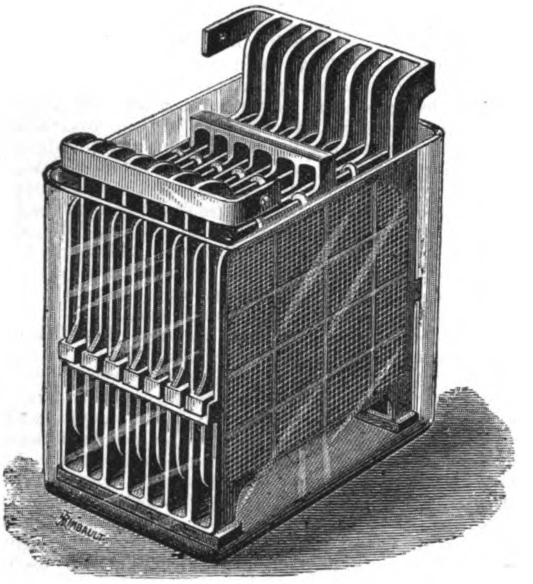

Fig. 1.

The negative plates of each cell rest on toes or blocks, and are maintained 1½in. clear of the bottom of the cell, and they suspend the positive plates by lead bars running along each side of the negative section, on which ebonite supports carry the positives. All the plates of each kind of each cell are welded or burnt on to a broad lead strip, to which either a terminal is attached, or which is burnt on to the strip of the next cell.

The "L" cells, for fixed permanent installations, are of glass, but for ship, tram, and train purposes they are generally fixed in wooden boxes, rendered water-tight by lead, marine glue, or ebonite linings.

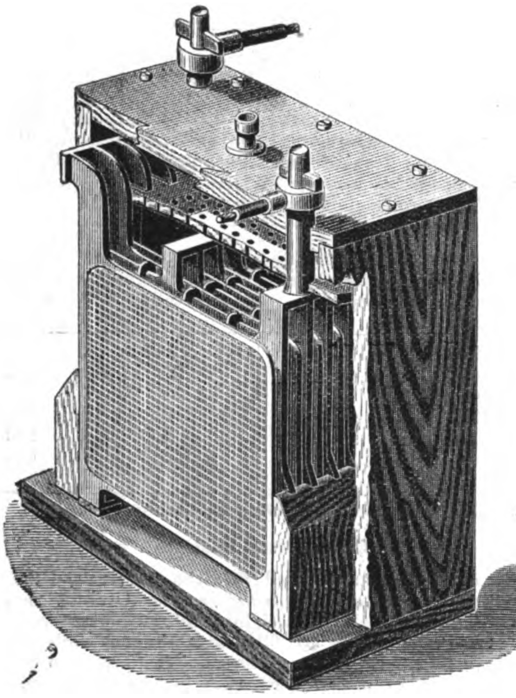

Fig. 2.

Glass is much preferable to wood, or to any opaque substance, for it is very useful to see how the plates and their packing are behaving. Elwell-Parker introduced a cell made of an in oxidisable alloy, but it has not been received with favour.

Glass has this advantage, that it is an excellent insulator, though owing to its hygroscopic tendency it has been found necessary in some cases to mount the cells on oil cups—a plan that is always necessary with wood and metal boxes.

The electrical leakage from glass cells when the acid spray is checked is very small indeed. They retain their charge unimpaired for months. It is, however, a good plan to paint the glass over with paraffin or vaseline occasionally. It checks leakage, and prevents the acid from creeping.

Elwell-Parker Cell.

The form of cell supplied by Elwell-Parker differs in several details from the E.P.S. pattern, though it is of the same type. The plates are held together by side frames of wood or vulcanite at the edges, so as to knit them together very firmly and prevent buckling. The whole frame of the largest size can be lifted in and out by a crane with ease. The negative plates are made in a way which prevents blistering, a defect in the E.P.S. plates, and the grids are burred in a way which prevents the pellets from dropping out. This process, due to Messrs. Drake and Gorham, is an important improvement.

Charging.

A diagram is now shown indicating the performance of 24 new E.P.S. cells when freshly supplied with sulphuric acid solution of 1·155 to 1·160 density, and charged by current for the first time. It will be seen that 39 hours and an average of 30 amperes were spent in bringing them up to the mark. Thus 1·170 ampere-hours were expended in the first charge. It is curious to observe how the density fell owing to the formation of lead sulphate. The cells rested during the night. Only four cells are shown as regards density, but they were all carefully measured by hydrometer. Gladstone and Tribe* have taught us that the principal chemical change that goes on in the cell is the gradual formation and reduction of lead sulphate $(Pb\,So_4)$, and the various changes that occur in the density of the electrolyte are due to these operations.

Capacity.

The capacity of a cell is the amount of energy it will accumulate and usefully restore. It is measured roughly either in ampere-hours or in watt-hours. The latter is the more accurate if the fall of E.M.F. is carefully noted, but if the E.M.F. is maintained fairly constant by not running the cells too low, the former is equally practical and more common. The average type of cell, such as the stationary E.P.S. pattern, gives a useful capacity of 4 ampere-hours per lb. of plates complete. I have had a cell (Fitzgerald's lithanode) which gave a return as high as 5·7 ampere-hours per lb., while the Planté type rarely exceed 2 ampere-hours per lb. The portable form used for traction purposes gives 5 ampere-hours per lb., but this is only because the plates are much lighter.

Efficiency.

The efficiency of a cell is the ratio between the energy taken out of it to the energy put into it, and the useful efficiency is usually taken from the number of ampere-hours discharged when the E.M.F. falls 10 per cent. in magnitude. This figure is a very variable quantity, for it depends very much on the current density—that is, upon the number of amperes per unit of surface—one square centimetre—of plate. The following experiment on a small cell illustrates this point:

Current density.	Ampere-hours.
·013	44·6
·048	36·5
·09	30·2

The ordinary current density, which should not be exceeded in practice, is ·01. This means that the maximum output should not exceed 4 amperes per positive plate.

A cell will discharge many more ampere-hours than are given by this useful efficiency, and if the discharge be taken with a very small density, the efficiency may reach a very high figure. Thus 95 and 98 per cent. have been obtained from small cells slowly discharged. The efficiency of a cell therefore varies with its rate of discharge. If the efficiency, with an output of 5 amperes, be 90 per cent., it will be only 50 per cent. with a discharge of 40 amperes. Batteries drop in E.M.F. if the rate of discharge is high, or the current density great. They should therefore be discharged at a slow rate. The most general maximum rate is found to be that which discharges a cell in ten hours. Thus, the discharge of 15 L cells should not exceed 30 amperes, nor that of 31 L cells 60 amperes.

It is sometimes thought that because the E.M.F. in charging is 25 per cent. greater than in discharging, there must be a loss of energy to that amount, but the fact is this loss of E.M.F. is compensated for by gain of current, owing to the reduction in the internal resistance of the cell. The internal resistance of a cell, which is normally about $\cdot0003\omega$ per positive plate, diminishes with the strength of the current of discharge, and therefore it is possible to get nearly all of the energy out of a cell that has been put into it. The efficiency of a secondary battery increases with the lightness of the load put upon it, and in this respect it possesses a great advantage over that other transformer of electric energy—namely, the secondary generator of Gaulard.

It has been the practice to place the plates in a cell very much too close to each other. This not only favours short-circuiting, but it prevents the free circulation of the electrolyte. Recent experiments have also shown that efficiency has also been improved by increasing the distance between the plates. I exhibit a diagram, through the kindness of Mr. King, illustrating this useful fact—a fact fully confirmed by my own experience with Planté cells.

The Electrolyte.

The character and the quality of the electrolyte used in secondary cells has scarcely received the attention it deserves. Hitherto scarcely anything but a solution of sulphuric acid has been employed. Experience seems to show that the best solution to use before charging is one which has a density of 1·150. Such a solution in a 15 L cell, when fully charged, will acquire a density of from 1·210 to 1·220, and it is customary to maintain the density of the cells somewhat between 1·170 and the higher figure. One of the great troubles with secondary cells that are imperfectly and improperly

* "The Chemistry of the Secondary Batteries of Planté and Faure," by J. H. Gladstone and Alfred Tribe. "Nature Series," Macmillan.

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treated is the formation of the white sulphate of lead that is frequently seen upon both plates. In fact, it is the root of nearly all the ills that these cells are heir to. There are many ways of getting rid of this sulphating. The plan used by Mr. Sayers, the engineer in charge of the St. Pancras Hotel installation, is described by him as follows:

"Our battery of 120 15 L cells was rather badly covered with sulphate of lead. At first I simply charged them with the ordinary maximum charging current—30 amperes—when each cell, on becoming full, would give about 2·5 volts. The sulphate, however, did not apparently move. I then tried charging with 40 or 45 amperes for a few weeks, and the change in the look of the plates—of the peroxide plate chiefly—was considerable. They began to exhibit patches of the well-known plum-coloured peroxide, and nearly all had the appearance of a peroxide plate covered with a lace-work of sulphate of lead. This lace-work, also, soon nearly entirely disappeared, and the majority of the plates are now looking very well. The E.M.F. of each cell, with 40 amperes charging current, is about 2·7 volts when the cell is milky. I have thought that this result was due either to the fact—if it is a fact—that sulphate of lead required more than 2·5 volts to decompose it thoroughly, say 2·6 volts, or, that the large quantities of nascent hydrogen attack the sulphate and combine, making sulphuric acid and lead."

It occurred, however, in 1886, to Mr. Barber-Starkey, of Aldenham Park, near Bridgnorth, to see if carbonate of soda, in the presence of lead, had any beneficial effect upon plates liable to sulphating. The result was very satisfactory, all traces of sulphating disappeared. He treated his own cells in this way, and the effect was so decidedly advantageous to all appearances, that I determined, after careful inspection and enquiry, to make an exhaustive experiment that should determine the question, and at the same time settle the best proportion to use. Six new 15 L cells of the Elwell-Parker make were taken, and they were charged with solutions in the following manner: No. 1—5 pints of sulphuric acid, 5 pints of sulphate of sodium, 15 pints of water; No. 2—5 pints of sulphuric acid, 4 pints of sulphate of sodium, 16 pints of water; No. 3—5 pints of sulphuric acid, 3 pints of sulphate of sodium, 17 pints of water; No. 4—5 pints of sulphuric acid, 2 pints of sulphate of sodium, 18 pints of water; No. 5—5 pints of sulphuric acid, 1 pint of sulphate of sodium, 19 pints of water; No. 6—5 pints of sulphuric acid to 20 pints of water.

The sulphate of sodium solution was prepared by first making a saturated solution of carbonate of soda (ordinary washing soda), and then adding thereto sulphuric acid until effervescence ceased. The cells so prepared have been charged and discharged, and watched with great care from May 1, 1888, until the present day. We therefore have exactly 12 months' experience of their behaviour, and there can be no doubt as to the beneficial result. The solution marked No. 5 is that which has given the best results, and after about six months' experience of its behaviour two complete sets of 52 No. 23 L cells were charged, the one with the ordinary sulphuric acid solution of 1·175 density, and the other with sulphate of sodium solution of 1·225 density. Six months' experience of these two sets has confirmed the result that immense benefit is to be derived from the sulphate of sodium solution. There has been no evidence of buckling, there has been little or no scaling. The bottom of the cells are nearly as clean as when they were first charged, while the bottom of those charged with the sulphuric acid solution have the usual accumulation of oxides of lead. Two cells were also, and at the same time, charged, the one with the sulphuric acid, and the other with the sodium solution, and very careful tests of these two cells show that the addition of soda does not impair either the E.M.F. or the internal resistance, nor does it diminish the output of the cells. I have, therefore, come to the conclusion that the addition of soda has a distinct beneficial result, and it is my intention to use it invariably in future. The cells so provided remain in splendid condition. They can be left for months without developing any trace of sulphating or even of loss of charge. Carbonate of soda thrown into a badly sulphated cell unquestionably leads to the rapid removal of the sulphate of lead, and always produces beautiful deep puce-coloured peroxide of lead.

Mr. R. Davids writes, January 18, 1889, to me from Campinas, Brazil: "As might have been expected, the cells (which had been delayed in transit) were very badly sulphated, but after 24 hours charging, I gave them a dose of soda, which proved a *santo remedio.*"

The electrolyte that I recommend for adoption is this: To a quart of saturated carbonate of soda solution add slowly, during continuous agitation, 12 fluid ounces of strong sulphuric acid; fill the cell with water 19 parts, strong sulphuric acid 5 parts, soda solution 1 part; total 25 parts. The specific gravity of this electrolyte should be 1·210.

It is a mistake to use cells of too small a capacity for stationary purposes. This is usually done for economical reasons, owing to the capital expenditure involved in purchasing cells. Twenty-six 15 L cells cost £78, and the same number of 23 L cells cost £117, and I believe it to be true economy to expend the additional £39. Greater efficiency is obtained out of the larger cells now that soda has prevented injurious sulphating, for you are not limited to a minimum current as you are with the sulphuric acid solution. Small charging and discharging currents mean not only greater efficiency, but greater durability of the plates. Secondary batteries used for telegraphy show no sign of disintegration. It is over-taxing cells that destroys the plates. Mr. Barber Starkey's cells at Aldenham Park have now been in use for three years, and to all appearances they are quite as perfect now as when first set up.

Maintenance.

The chief secret of the successful working of a set of secondary cells is careful and regular attention to their behaviour, and the immediate remedy of any defect that may develop. They require daily testing and inspection. My battery is tested every morning for E.M.F. by means of a Cardew's voltmeter. If the total number of volts divided by the number of cells is not over 2 per cent., each cell is tested separately by a portable Walsall voltmeter graduated to tenths of a volt, until the defective cell is found. This has very rarely happened, in fact, only once during the past 12 months, when a plugging fell out, rested between the two plates, and short-circuited the cell.

Six cells are also tested every morning for density by a hydrometer, which is recorded in a book. The six cells are changed every month, so that each cell of the battery passes through this ordeal three times a year. The regular rise and fall of the specific gravity of a cell is the very best criterion one can have of its good working. I cannot do better than transcribe the record of one week's testing (see table A.)

Table A.—"Gothic Lodge" Engine-room. 28 E.P.S. Cells.

Date.	Current.	E.M.F.	Cells (Density).*				
			8	14	18	20	26
April 24		57·5	1,210	1,215	1,190	1,225	1,225
" 25		57·5	1,210	1,205	1,185	1,220	1,220
" 26		57·	1,205	1,195	1,180	1,215	1,215
" 27	Charging						
7.30 A.M. ...	26½	60	1,200	1,190	1,175	1,210	1,210
10.0 ...	30	64	1,205	1,195	1,180	1,215	1,215
12.0 ...	31	67	1,210	1,200	1,185	1,220	1,220
2.0 ...	31	69	1,210	1,205	1,190	1,225	1,225
4.0 ...	31	70	1,210	1,210	1,200	1,225	1,225
April 28 ...	—	57·5	1,210	1,205	1,195	1,225	1,225
" 29	—	57·4	1,205	1,200	1,190	1,220	1,220

* The density of the cells requires to be equalised periodically.

The normal density when the cells are charged should be 1·220. They fall 1 for every 5 ampere-hours taken out, and when they reach 1·150 they are exhausted. The density is thus a record of the energy that has been taken out, and of that which remains in.

Occasionally, I test them for internal resistance (ρ), both when charging and discharging. In the latter case the discharge current into the house is regulated by lamps to give 10 amperes when the E.M.F. (E_1) at the terminals is read. The E.M.F., when the ends are free (E_2), is also read. Then,

$$\frac{E_2 - E_1}{10} = \rho$$

I make the current 10, for the internal resistance varies with the current,* and by always using the same current I have an accurate comparison. The internal resistance of my 15 L cells is usually ·0012 ohm per cell when discharging, and ·005 when being charged.

When a cell becomes defective by short-circuiting, or any other cause, the plates are taken out, their faces scraped and straightened, the solution cleared, and the cell thoroughly cleaned. The cell is always benefited by such a process, for the cleaned cell is always the first to come up to the charge by as much as 1½ hour.

The cells in this building have been very carefully tended during the four years they have been at work. Only three sets of positive plates have been renewed.

In charging cells, there are three distinct indications that the cell is fully charged: 1. The E.M.F. suddenly rises up to 2·5 volts per cell. 2. The hydrometer indicates 1·220. 3. The electrolyte becomes milky by the fine bubbles of gas that float in the disturbed solution during their gradual ascent to the surface, and escape into the air.

The rise of bubbles of gas to the surface, and their bursting, scattered a considerable amount of acid spray about in the battery-room, which was injurious to metals and apparatus; but Mr. F. Higgins, M.I.E.E., showed how to prevent this by covering the cell with a fine net or with calico. Glass plates are now much used instead of calico, but I have adopted Mr. Henry Edmunds' plan of pouring upon the surface of the solution melted paraffin, which solidifies and coats the surface with a uniform thin layer of what looks like ice. A hole is bored to admit the hydrometer, and to allow any gases to escape.

It is necessary to be cautious in approaching cells with naked lights when they are being charged. There are several instances of explosion and injury to person in consequence. Two cases in London and two in Leeds have come under my own notice; one was in the Post Office.

The chief defect of the negative plate is that the plugging scales and falls off in thin flakes. This, in the recent types, falls harmlessly to the bottom, but it should not happen at all, and it is due either to imperfect material or to hasty formation. The negative plate should certainly last for ten years. The positive plates also disintegrate, and to a much greater extent. The disintegration of the lead peroxide seems to be necessary consequence of the action of the cell. It varies with the rate of discharge. If the cells be worked heavily it occurs rapidly, but if the maximum rate of the output of about four amperes per plate be adhered to, the duration of the plate may be taken to be three years. The decay of the positive plate seems to occur almost entirely in the lower half of the plate, and this is probably due to the greater density of the solution favouring unequal distribution of current.

(To be concluded).

* Preece, *Proc.* R.S., May 6, 1885

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IMPORTANT NOTICE.

Although the Paris Exhibition is open, the major portion of the exhibits are in so backward a state that any systematic description is almost impossible at present, so we shall wait a short time till the chaos of packing cases becomes a neat arrangement of exhibits. It is needless to tell our readers that—so far as our description of the electrical exhibits is concerned—our attention will, in the first place, be directed to the interests of English and American exhibitors. A special edition of this paper, with the report of the exhibition in two languages—English and French—will be obtainable in the Exhibition.

THE MINER'S LAMP.

The conversazione of the Royal Society not infrequently brings into notice apparatus of a very interesting character, and more especially devised for use in purely experimental work. Occasionally, however, apparatus of wider utility is shown, and that seems to have been the case this year, when Pitkin and Niblett's gas detectors were shown. Two directions have long been invitingly open to electrical inventors, and both now seem in a fair way to be filled. Ganz and Co. promise an alternate current motor, and the invention to which we now direct attention appears to offer a better solution to another problem than anything that has gone before. The miner's life at its best is a hard one, the dangers he braves and the work he does are but inadequately rewarded. There is a vast and profitable field for the use of any invention that will assist to ease the labour and reduce the danger. Such an invention many see in the application of electricity to miners' lamps. The requirements of a perfect miner's lamp, however, are not easily met, and work in the direction of supplying such lamps has not moved proportionally to the supply of electrical apparatus for lighting purposes in other directions, such, for example, as ship lighting. The miner's lamp must be cheap, not too heavy, certain in its action, capable of giving its light over a long period of time, safe from the possibility of igniting the firedamp, and able to indicate the presence of inflammable gases in dangerous quantities.

A number of lamps, actuated by primary or secondary batteries, have been devised, but none so far possess all the requisite qualities to enable one to say, this is the ideal lamp. Some of those in the market are ingenious and beautiful productions. Mr. Swan, seeing the absolute necessity of a gas detector, has added such to his lamp, but it has one great objection in that it is not automatic in its action. The miner at the face of the coal has to leave off his work, and manipulate the apparatus in order to see the state of the air in the working. As a matter of fact, the men cannot be expected to do this; their whole attention is required by their work, and time cannot be wasted in manipulating even the simplest apparatus. Otherwise, we have looked upon Mr. Swan's device as exceedingly ingenious. Whether Messrs. Pitkin and Niblett have solved the question we cannot say—to our mind the arrangement promises fairly—and we should require to know the results of a number of crucial experiments before giving adhesion to its perfection. The inventors are more deeply interested in studying the instrument than outsiders, and may, perhaps, at once be able to answer satisfactorily the questions which arise. In the first place, the instrument consists of two thermometers, one of which gives the ordinary reading due to the temperature of the air in contact with

the bulb, the other gives a reading due to heat development caused by the gaseous mixture in which it is placed acting upon spongy platinum or some similar metal—the precise chemist might say, through the action of the spongy platinum bringing about chemical combinations of some of the constituents of the mixture. Platinum has a remarkable power of causing the combination of oxygen with hydrogen and other combustible gases. "This property is exhibited even by a clean surface of platinum, in a greater degree by platinum in the spongy state, and most of all by the extremely divided form of the metal called platinum-black," *vide* Watts' Dict., vol. iv., p. 665. Now, if one of the thermometer bulbs is coated with platinum-black, and the platinum-black has the power to cause the combination of oxygen with the inflammable gas in a mine, thereby heating the platinum-black, the mercury will rise in the thermometer. If the heating thus effected is in proportion to the percentage of inflammable gas, then the rise of mercury will be proportional to that percentage. At this point an exceedingly grave question comes in. We assume that up to a certain point the heat of combination is used in heating the metals, and will not tend to ignite the surrounding inflammable mixture—in fact, that the spongy platinum acts like the gauze of a Davy lamp; but is not a point soon reached, when the temperature of the small quantity of spongy platinum used is sufficiently high to cause general combination. In other words, does it not again act like a Davy lamp, which, as is well known, may get too hot to be safe? Then, again, it must be ascertained whether the spongy platinum deteriorates in action, or whether it gets tired, and how, if it gets tired, the fact may be known to the lamp-minder. Again, is its action continuous—that is, if placed in a mixture, will it continuously indicate the presence of the adulterant gas, or will it indicate but momentarily or shortly?

The instrument can be made in a variety of forms. A suggested use, which commends itself to us, if the above questions are answered satisfactorily, is to fix it behind the incandescent lamp of the miner's lamp, making the dial of the instrument the reflector of the lamp, with the dark pointer across the dial. Every glance at the lamp would show the position of the pointer and the condition of the mine. A small bell could also be affixed to the lamp, and when mercury or pointer came to "danger signal," contact could be made, and the bell would ring out its warning sound. This might prove more useful than a pointer, because the miner might be too intent on his work to notice the position of the pointer, or a sudden influx of gas cause danger when a moment before there was no danger. The ringing of the bell would hardly fail to attract attention.

We have still one more question to ask. It is evident the action of this instrument is limited in range. Taking it that the inflammable gas in a mine is marsh gas ($C H_4$), and that it requires ten times its volume of air to cause an explosive mixture, or, as the miner would put it, five volumes to become dangerous, the range required through which an instrument must be effective, is soon ascertained. Have the inventors determined the range? These are a few of the questions which present themselves upon the introduction of this instrument. For the sake of the miners we sincerely hope that it is perfect, or can be made perfect. Combined with an electric lamp, it would give a more effective lamp than any at present used, and the introduction of such a combination into our mines would be exceedingly rapid. It must not be for a moment supposed that miners or owners object to the introduction of better lighting. They do not; both men and masters are anxious for it, but they will not accept the imperfect lamps that have hitherto been put forward as substitutes for the Davy, Clany, or other forms.

THE EFFICIENCY OF METHODS OF ARTIFICIAL ILLUMINATION.*

BY EDWARD L. NICHOLS, PROF. OF PHYSICS IN CORNELL UNIVERSITY.

(Continued from page 353.)

The curve of luminous radiation corresponds in form with that of candle-power. The distribution of total radiation, however, differs widely from these and the ratio, $\frac{\text{luminous energy}}{\text{total energy}}$, is a function of the angle which the line of measurement makes with the horizontal plane. The values of the efficiency in the case in question for the various angles at which measurements were made, are given in table III. They form the basis for the curve in Fig. 6, which is the diagram of efficiencies of the arc light under the conditions of operation already stated.

TABLE III.

Efficiency of an arc lamp; after measurements by H. Nakano:

Angle.	Efficiency = $\frac{\text{Luminous radiation}}{\text{Total radiation}}$
0°	·0548
10°	·0901
20°	·1228
30°	·1506
40°	·1552
50°	·1059
60°	·0676
63°	·0492

The integration of these values gives as the mean efficiency of the arc lamp in question, ·104, or 10·4 per cent.

The ratio of the radii of two semi-circles, the areas of which equal the areas enclosed by the curves of luminous and total radiation, gives us a measure of the "mean spherical" efficiency of the lamp. This ratio in the case of the lamp to which these curves refer is very much smaller than the generally accepted values of the efficiency of arc lamps, expressed in terms of the candle-power per watt, would lead us to expect. The intensity of the arc is, however, seldom expressed in mean spherical candles, and there are few data relating to the candle-power of this source of light upon which to found satisfactory estimates. On the one hand

* A paper read before the American Institute of Electrical Engineers, March 12, 1889.

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we find it stated, doubtless correctly, that the mean light-producing efficiency of the 11 dynamos tested at the International Health Exhibition, held in London in 1884, was 1,440 candles per horse-power,* while the glow lamps only yielded 175 candles, and it is with estimates similar to the above with which we have generally to satisfy ourselves in comparing arc and incandescent systems of illumination.

For the purpose of deciding whether the results of Nakano's method of determining the ratio of luminous to total radiation are compatible with our other sources of knowledge concerning the arc light, we must make use of mean spherical candle-power as our basis of comparison.

Very careful measurements of the mean spherical candle-power of two arc lamps of representative and successful commercial types were made in the physical laboratory of Cornell University,† following the method of the Franklin Institute committee. Both of these lamps were rated at 2,000 c.p. They were maintained by dynamos of the types for which they had been especially designed, working under normal conditions. One of the lamps gave a mean spherical c.p. of 295, when working in series with nine other lamps of the same construction. When placed in circuit alone the c.p. rose to 348. The energy expended in the lamp in each case was 550 watts, and the efficiency accordingly 1·8 watts and 1·6 watts per candle.

The other lamp was found to reach 609 mean spherical candles at the cost of 601 watts. An inspection of the result obtained by the Franklin Institute committee would lead us to regard these as extreme values, between which the performance of almost all arc light would lie as a rule, nearer the lower than the upper of these limits. The efficiency of arc lights, then, expressed in mean spherical candle-power per watt is frequently as low as 1·5 times that of the incandescent lamp, and rarely three times as high. Now, the mean efficiency of the arc lamp under discussion, *i.e.*, the ratio, $\frac{\text{luminous radiation}}{\text{total radiation}}$, according to the measurements of Mr. Nakano, is almost exactly 10 per cent. The efficiency of incandescent lamps, defined in the same way, according to Mr. Merritt, may, as we have seen, be taken at about 5 per cent. The ratio is 2:1 in favour of the arc lamp which lies within the limits determined by comparison of candle-power and watts.

Small as these values for the efficiency of the electric light are, they show marked improvement over the efficiency determined in a similar manner for sources of illumination which depend upon the incandescence of carbon by direct combustion. More than a quarter of a century ago, Julius Thomsen‡ presented before a gathering of Swedish men of science the results of an investigation of the energy consumed in the sperm candle, and in various oil and gas flames. His memoir bore the suggestive title of the "Mechanical Equivalent of Light," and is one of the earliest contributions to our knowledge of the energy of luminous radiation.

The instruments employed in Thomsen's experiments were the thermopile and galvanometer, the indications of which were reduced to absolute measure by determination of the deflection produced by the radiation from a glass globe filled with hot water. The total loss of heat by radiation which this globe suffered was calculated from its rate of cooling, using Dulong and Petit's law. The water equivalent of the globe was 1,351 grains; its total loss of heat per minute at 50deg. C. was 250 calories; its loss of heat by radiation at the above temperature, when the air of the room was at 17deg., was 102 calories per minute. Under these conditions the influence of the globe of water upon the thermopile placed at a given distance, was observed. A luminous body having been substituted for the globe, its influence on the pile was likewise noted, and its total radiations in calories calculated by comparison of the deflections produced in the two cases.

For a sperm candle burning 8·2 grains per hour, the total radiation estimated by this method was 210 calories per minute. Other flames gave out proportions of heat nearly in proportion to their candle-power, as will be seen by inspection of table IV.

TABLE IV.

Calories per candle-power radiated by various flames, according to Julius Thomsen:

Source of illumination.	Candle-power.	Calories per candle.
Sperm candle	1·	210
Gas flame	1·2	201
Gas flame	7·7	199
Moderator lamp	8·6	199

The luminous energy was obtained by a method similar to that pursued by Merritt in the experiments already described. A bath containing a layer of water 20 c.m. in thickness was interposed between the lamp and the thermopile, and the indications of the galvanometer noted. The results were based upon the assumption that the cell absorbed 13 per cent. of the light and all of the dark rays. This estimate is doubtless faulty, and may involve a reduction of several per cent. from the values given by Thomsen. His results, uncorrected, are as follows:

TABLE V.

Energy of luminous radiation of various flames in calories, according to Julius Thomsen.

Source.	Candle-power.	Luminous energy. per c.p.
Candles	1·	4·4 calories.
Moderator lamp	6·25	3·9 calories.
Moderator lamp	8·6	4·1 calories.
Gas	7·7	4·2 calories.
Gas	1·2	3·7 calories.

The enery of the light-giving rays per candle-power of light produced is then, according to Thomsen, very nearly the same for the flames of the candle, oil lamp, and gas-burner. This conclusion has been abundantly confirmed by spectro-photometric observations of the quality of the light which they emit. It appears, moreover, from these observations, of which I shall have occasion to speak at length presently, that the temperature of the incandescent particles in such flames agrees very closely indeed with that of an incandescent lamp, consuming 5 watts at 16 c.p., being, as a rule, lower rather than higher than the latter; and the calculation of the energy of such a lamp in calories per minute, making use of the data furnished us by the investigation of Abney and Festing, or of Merritt, affords most satisfactory evidence of the accuracy of Thomsen's results. Let us take, for example, the case of an incandescent lamp, in which 5 watts per candle-power are expended, and in which the ratio

$$\frac{\text{Luminous radiation}}{\text{Total radiation}} = \cdot 05.$$

The energy converted into light in such a lamp is ·25 watt.

Now, 1 gramme calorie = $4{\cdot}2 \times 10^7$ ergs.

$$1 \text{ watt} = 10^7 \text{ ergs} = \frac{1}{4\;2} \text{ gramme-calories per second.}$$

$$\cdot 25 \text{ watt} = \frac{25 \times 60}{4{\cdot}2} \text{ gramme-calories per minute, and the}$$

heat equivalent of the luminous energy is 3·6 gramme-calories per minute.

This value is somewhat smaller than those given by Thomsen in the preceding table, but proper corrections for the diathermancy of the water bath used in his experiments and for the difference in standards of candle-power —the light given by his sperm candle being slightly in excess of the legal standard of the present day—will bring the two into excellent agreement.

The entire energy developed by the chemical reactions occurring in these flames per candle-power of the light produced were, however, about 1,400 calories in the case of candle and oil lamps, and 4,100 calories in the case of gas, so that the gross efficiency would be respectively ·3 per cent. and ·1 per cent. The average ratio of total radiation reaching the thermopile to luminous radiation is about ·2 per cent.; but this ratio cannot be considered in the same light as that obtained in the case of the incandescent lamp, since a gas or oil flame is in reality a column of heated vapour containing particles of unconsumed carbon, which reaches far above the luminous region, sending out dark

* Julius Maier: "Arc and Glow Lamps," p. 52.

† "The Photometry of Arc Lights." Thesis by Benjamin W. Snow, 1885. MS. in the library of Cornell University.

‡ Julius Thomsen: "Das Mechanische Æquivalent des Lichtes;" *Poggendorff's Annalen. Bd.* 125, p. 348.

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rays from its upper and cooler portions, which do not reach the face of the thermopile at all. The relation which the total radiation of this heated column bears to the heat dissipated by convection cannot be determined, and the determination of total radiation from the light-giving portions alone is of little value. It is only in the matter of gross efficiency, therefore, that we can institute a comparison between electric lamps and the older methods of illumination, and the gross efficiency of the former depends upon the efficiency of production of electric current. Under conditions, such that 10 per cent. of the total energy of the fuel consumed is converted into electricity—conditions which are, I believe, rarely attained by our present methods—the gross efficiency of an incandescent lamp, of which the net efficiency, determined by the methods which I have already described, is 5 per cent., would be ·5 per cent.; a value which is five times greater than that of a lamp burning the kind of gas used by Thomsen, and which stands in the ratio 5 : 3 (or, probably, rather more than that) to the gross efficiency of an oil flame. These flames must, of necessity, vary very widely with the quality of the fuel consumed, and with the condition under which combustion is maintained.

If we apply a similar method of computation to the values given by Mr. Preece in his recent address at the Bath meeting of the British Association for the Advancement of Science*, assuming that the conditions under which each illuminant is consumed are such that the temperature of the incandescent carbon equals that which is maintained in the filament of an incandescent lamp at 5 watts per candle with a net efficiency, as before, of 5 per cent., a set of conditions which can be attained in practice only in the most perfectly constructed oil and gas lamps, and which are fulfilled in many of the best of our incandescent lamps of to-day, we obtain the following results.

TABLE VI.

Gross efficiency of various illuminants deduced from the values given by Preece. The heat equivalent of the candle is assumed to be 3·6 gramme-calories per minute.

Illuminant.	Watts per candle. (Preece.)	Gramme-calories per min. per candle.	Luminous radiation. / Total radiation = gross efficiency.
Tallow	124	1770·	·0C203
Wax........	94	1340·	00268
Sperm	86	1230·	·00293
Mineral oil	80	1143·	·00315
Vegetable oil	57	815·	·00442
Coal gas	68	971·	·00317
Cannel gas	48	685·	·00521

In considering these values it should be borne in mind that coal-gas is a fuel which has been obtained by the previous expenditure of considerable energy. Were we to take as our basis the consumption of coal necessary to the production of a candle-power of light, instead of the heat of the combustion within the gas flame itself, the values for the efficiency of coal-gas as an illuminant would be very considerably reduced.

We have already seen that there are excellent experimental grounds for the statement that the gross efficiency of the incandescent lamp is about ·005, and that of the arc lamp about ·01, under the assumption of the waste of 90 per cent. of the total energy of the fuel in the various processes leading to the production of the current, and that the latter figures, small as they are, are considerably in excess of the gross efficiency of candles, oil, or gas. We are in possession, moreover, of the means of expressing exactly the degree of superiority which the electric light possesses over those illuminants in the important matter of the heating effect upon the surrounding atmosphere. Gas and oil flames deliver in the neighbourhood of 1,000 gramme-calories of heat per minute to the room for each candle-power, of 3·6 gramme-calories of luminous radiation. An incandescent lamp of 5 per cent. net efficiency delivers only 72 gramme-calories per candle-power.

* Preece. Address before Section A. meeting of the B.A., at Bath, 1888. *Nature*, vol. 38, p. 496.

The net efficiency of the incandescent lamp may be raised somewhat by increasing the temperature of the carbon filament, and, indeed, it has already been somewhat raised by the introduction of the new "three watt" lamps. These lamps have been excluded from this discussion because we have as yet no complete data with reference to them, and because it seemed desirable, aside from that, to institute comparisons between sources of illumination in which the degree of incandescence was the same, and for all of which, consequently, candle-power had the same meaning.

When we raise the temperature of our source of light, however, we introduce changes of which the methods thus far considered take no cognisance.

In increasing the degree of incandescence, the ratio of luminous energy to total energy of radiation is slowly increased, and at the same time the relative brightness of the various rays which constitute the visible spectrum changes. In a word, the quality of the light changes, and we are confronted by important variations which cannot be expressed in candle-power.

The investigation of these changes in composition, upon which colour depends, involves the study of the visible spectrum of the source of light, and the comparison of its intensity, wave-length for wave-length, with the spectrum of some properly-chosen standard. The instrument necessary to this work is the spectro-photometer, by means of which the spectra of the two lights to be compared are brought together in the field of view, one above another, like wave-lengths everywhere in the same vertical line. The measurements consist in bringing the two spectra to the same intensity in each of the regions selected for observation successively, and in determining the amount by which it is necessary in each case to reduce the intensity of the brighter. A variety of devices have been made use of for varying the brightness of the spectra, and the standards of comparison adopted by different observers have included the candle, the petroleum flame, the gas flame, and the incandescent lamp, maintained at a constant voltage. Thus W. H. Pickering* obtained the necessary range of intensities by placing the lamp under inspection upon a sliding carriage, and varying its distance from the slit of the spectroscope. His standard of comparison was a gas flame. H. C. Vogel† used as his standard a petroleum flame. Crova,‡ who brought the intensities of the two spectra to equality by means of a polarising device, adopted the moderator lamp as a standard. Otto Schuman, in his study of the incandescent lamp, made use of a "benzine" candle. The intervention of a revolving disc with open and closed sectors and of wedges of smoked glass have also been applied to the regulation of the intensity, and the method of varying the width of the slit itself, a device due to Vierordt, has been found to give good results where the range of intensities was inconsiderable.

The methods of presenting the results of this class of measurement have differed as widely as the methods of observation and the choice of standards; but it is possible, wherever the data are properly given and the character of the standard is known, to reduce them all to a common basis of comparison. When thus reduced, these measurements are found to agree in all essential particulars, and they afford us very definite knowledge of the character of the light emitted by the sources of illumination to which the spectro-photometer has been applied.

Fig. 7 shows the form of the spectro-photometer recently used by W. S. Franklin and myself in an extended series of observations upon artificial sources of illumination, and in the comparison of their spectra with that of daylight.

To the slit of a one-prism spectroscope are attached a set of total reflection prisms, *r*, by means of which rays may be introduced into the upper and lower halves of the slit, these rays coming respectively from sources of illumination placed to the right and left hand in a line at right angles to the axis of the collimator tube. The standard of illumination, which is an incandescent lamp, S, maintained at 16 candles, is placed at the observer's right hand.

Its rays having been rendered parallel by means of a condensing lense, *l*, pass through a pair of Nicol's prisms, N

* W. H. Pickering, *Proceedings* of the American Academy of Arts and Sciences, vol. 15, 1880. † H. C. Vogel, *Berliner Monatsberichte*, 1880, p. 801. ‡ A. Crova, *Comptes Rendus*, 87, 1878, p. 322.

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and N′, the first of which is free to revolve, and enters the upper half of the slit. The intensity of the spectrum of this lamp can be reduced at will by the rotation of the first Nicol, and its brightness is calculated from the angle between the flames of polarisation of the two Nicols. To the left of the slit is mounted a block of magnesium carbonate, its face vertical, and forming an angle of 45deg., with the axis of collimation of the spectroscope. The rays of the source of light to be investigated, S′, which is placed at a convenient distance, fall upon the magnesium carbonate, and is such of the diffusely reflected rays from the latter as reach the total reflection prisms, and thus enter the lower half of the slit, which form the second spectrum.

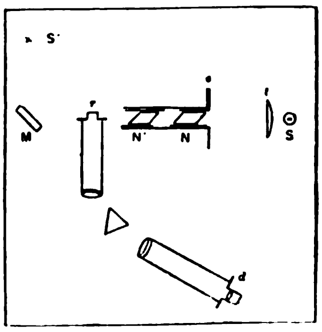


FIG. 7.

The object gained by the interposition of this white surface is an important one. All artificial light, except that from an incandescent lamp, emanates from glowing materials varying greatly in temperature, and the spectrum obtained directly from the source is always that due to some particular portion of the luminous body under investigation to the exclusion of the remainder, and differs more or less in character from that of the source taken as a whole.

(To be continued.)

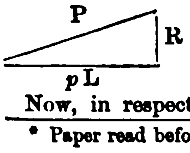
ON LIGHTNING, LIGHTNING CONDUCTORS, AND LIGHTNING PROTECTORS.*

BY DR. OLIVER LODGE, F.R.S., MEMBER.

(Continued from page 358.

Material of the Lightning Conductor.

25. A few words may suffice to explain the nature of the impedance which alternating currents meet with in passing through a conductor, and of the reason why iron is as good as, or even better than, copper for the purpose of conveying currents alternating with extreme rapidity. A rising current has to magnetise the space all around it, and the production of this magnetisation delays and impedes the rise of the current to its maximum value. A falling current permits the magnetisation of the space all round it to decay, and the dying out of this magnetisation delays and impedes the fall of the current to its minimum. The more rapidly the current changes, the more powerfully felt is the influence of the accompanying magnetisations and demagnetisations. Now, the total magnetisation produced by a current—its total number of lines of force, or its total "magnetic *induction*," as it is often called—is proportional to the current strength: equal to it multiplied by some constant, which we may call L, and write $I = L\,C$, where I is the total induction produced by the current C. L is a coefficient characteristic of the circuit, its value being defined by this equation, and is called the coefficient of induction excited by the current's own self, or the coefficient of self-induction. If the current goes through $p/2\pi$ complete alternations in a second, it can be shown that the impedance it meets with, due to the reversals and re-reversals of its own magnetic field, is p L. This is not the whole obstruction it meets with, but it is the only part which does not dissipate energy and cause its vibrations to decay. It may be called the *inertia* part of the impedance. The remaining part of the total impedance is resistance, R, the dissipation of energy coefficient, defined by heat per second $= R\,C^2$; and the total is the resultant of these two as if they were not right angles to each other. So that calling P the total impedance,



$$P^2 = (p\,L)^2 + R^2.$$

Now, in respect of the R term, iron is much worse than copper, not only seven times worse, 100 times worse; but then for very rapid alternations the R term is altogether insignificant compared with the p L term.

26. In respect of the p L term does the material of the conductor matter? Well, in so far as the magnetisation spoken of is that of the space surrounding the conductor, of course, the substance of the conductor itself matters nothing. But in so far as the conductor itself gets magnetised, the material of which it is made does matter. Now, a linear current magnetises at right angles to itself everything surrounding it—most intensely the things close to it. A hollow cylindrical current magnetises everything outside itself, but nothing inside. If the current were to distribute itself uniformly through the section of the wire, the outside of the wire would get magnetised in concentric cylinders; but if the current were to confine itself to the outer surface, and flow as a hollow cylinder, it would escape the necessity of magnetising the wire at all. In cases where the p L term is much more important than the R term this is precisely what it does therefore. It always flows so as to meet with the least possible total obstruction; and it finds less total obstruction by cramping itself into the periphery of the wire than it would find if it utilised the whole section. The cramping into the periphery increases R, but it decreases p L; and on the whole with rapidly alternating currents this is an advantage, and gives a smaller value to P. Slowly changing currents think most about R, and use the biggest cross-section they can find. Rapidly changing currents think most about p L, and avoid having to magnetise more than they need. Especially must they avoid having to magnetise the conductor if it consists of iron: hence in that case they cramp themselves tremendously into its outer skin, and thereby avoid having to overcome much more total impedance than they meet with in the case of copper; but though they thus keep down impedance, they increase their dissipation of energy term, and get their oscillations damped out far more quickly than when they only have to pass through copper. The violence of the flash, therefore, subsides more quickly in an iron than it does in a copper conductor; and so I find it experimentally. Nothing here said is in the least hypothetical. It is all absolutely clear and certain, and has been abundantly verified. I will not go into the history of the subject. It is well known.

27. Let it be clearly understood, once for all, that in comparing copper and iron conductors I never mean comparing them as of unequal thickness—*i.e.*, of equal conductivity. Such a comparison is ridiculous in the present state of knowledge. They are to be compared when of the same thickness; and under those circumstances I assert iron to be a trifle better, certainly not a whit worse, than copper, irrespective of all its other manifest advantages—cheapness, fusing-point, etc., etc. Want of flexibility is sometimes urged against iron, but stout telegraph wire is flexible enough; and, until experience decides to the contrary, I feel sure it is thick enough for lightning-conductors. The one and only thing on which anything can be said against iron is on the subject of its durability, and this being a chemical question I offer no positive opinion; at the same time I am absolutely certain that any slight disadvantage in that respect is a hundredfold compensated in most localities by its other superlative advantages.

Current and Potentials during Discharge.

28. In cases where a conductor is pretty thick—say, anything like a quarter inch diameter, or even a tenth, and of any moderate length, such as 100 yards or less (not many miles), the two terms of impedance are so unequal that is for many purposes needless to think about R at all, the impedance is practically p L simply; and this, as I have shown in *Phil. Mag.*, August, 1887, is under any given circumstances half the critical *resistance* which determines whether the discharge shall be oscillatory or not under the same circumstances. The total impedance is commonly to be reckoned in hundreds or even thousands of ohms.

29. The strength of current passing in the alternations can be estimated by considering that the whole quantity stored up in the discharged body has to be transmitted in a quarter of one oscillation period—say, for instance, in the millionth of a second. If the quantity discharged were one coulomb, this would mean a current of a million amperes. In any case the current must be hundreds or thousands of amperes.

30. The difference of potential needed to drive so strong a current through so great an obstruction is enormous, being equal to the product P C, and may be reckoned in millions or hundreds of millions of volts; hence it is that lightning-conductors afford an easy path for lightning, but that it tends to spit off in all directions, even to what would seem, and, indeed, are, very inferior conductors. It will spit off from a well-earthed stout copper rod to bits of wood, and to perfectly insulated bodies.

Effects in the Neighbourhood of a Discharge.

31. Putting together the enormous electrostatic potentials existing at the different points of a conductor conveying a discharge, and the violent oscillation to which so strong a current is subject, we perceive how great must be both the electrostatic and the electromagnetic induction in all space anywhere near it

* Paper read before the Institution of Electrical Engineers.

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These disturbances, thus rendered certain and accounted for, can easily be experienced experimentally. I proceed to relate a few experiments out of a multitude which I have made.

32. I took a considerable length of highest conductivity, No. 0 electrolytic copper wire, kindly lent me by Messrs. Thomas Bolton and Sons, and arranging one end so as to be accessible to Leyden jars, etc., carried the wire up to a high gallery and then down to earth. Earth was made in several ways on different occasions, water-pipes, gaspipes, hot-water-pipes which ramified the whole building, outside gas mains, bars buried in ground; but the most effective and indeed perfect return circuit could be had when wanted by connecting the end metallically with the outside coat of the jar, without any earth contact at all. When this direct contact was not made, the outer coat of jar had of course to be connected to earth also, in order to complete the circuit. Very often they were both connected to each other and to earth as well. It makes no essential difference; whatever may be considered the most satisfactory method, that may be adopted, and the phenomena will go on just as well. They may be briefly summarised as follows:

(1) If the conductor pass within an inch or two of any uninsulated piece of metal, it gives off a violent side flash to it.*

(2) If the far end of the conductor is neither earthed nor connected to jar, but is left insulated in air, side-flashing from it occurs a trifle more easily, but not very markedly so.

If the conductor pass within, say, ½in. of an insulated conductor, it gives off a side flash to it. The strength of the flash depends on the capacity of the insulated conductor, being considerable if it be large; but some side spark occurs to an absurdly small body perfectly insulated—*e.g.*, such a thing as a coin on a stick of sealing-wax—and this when the conductor is absolutely well earthed at its far end.

(3). Sparks can be obtained from everything, even quite uninsulated things, connected to the conductor. For instance, if it be connected to the gaspipes, small sparks will fly to the finger or to an insulated body from all the gas-brackets about, and these sparks are sufficient to ignite gas.

(4). Sparks can be obtained between the ends of any long curved conductor, be it insulated or uninsulated, if they are brought close enough together to form a nearly closed circuit.

(5). Sparks can be obtained from or between insulated bodies in the neighbourhood of the conductor, and not connected to it at all, every time a flash occurs. For instance, a large piece of wire gauze connected to nothing gave off sparks to a gas-bracket and ignited the gas. Moreover, one piece of wire gauze sparked small sparks into another, neither connected with anything.

In illustration of this, some gilt key pattern high up on the wall of the hall, 25, Great George-street, was seen to be sparking while Leyden jar discharges were going on through a wire lying on the floor. They were not so bright as the sparkings at the Royal Institute wall paper, but the gilding was further from my wire, and I believe is quite far from any wire. As illustrating the motive current produced in conductors during the act of reflecting electromagnetic waves, they were therefore still more satisfactory.

(6). Sparks can be obtained from quite uninsulated bodies, even when not connected with the conductor—*e.g.*, from hot-water pipes, from gaspipes, from water-pipes, from strips of brass let into the table, from gas-brackets in other rooms, from a wire lying on the floor of a distant corridor; and, in fact, all over the building with few exceptions. The sparks can be taken by a penknife held in the hand; sometimes they can be taken to the knuckle or finger-tip even when pressed against them.

(7). Sparks can be got to pass between two totally uninsulated things, neither of which have any connection with the lightning-conductor. For instance, let the conductor be thoroughly earthed in some outdoor and distant manner, and under favourable circumstances a bright short spark can be seen passing at every discharge between a gas-tap and a water-tap of my lecture-table which happen to approach each other closely. Let the gas escape near these sparks and it ignites.

(8). Sparks can be got between two thinly-insulated electric-light wires if they lie close enough together, and if a storage battery be connected to them an arc will be started, destroying the insulation and burning the wires.

(9). If at any distant place, or out of doors in daytime, the sparks are too feeble to be seen, disturbances can still be easily detected by means of a telephone; connecting one terminal to the thing—say, the roof, a shed, or a wire fence—and holding the other end in one hand. Or, of course, by connecting the two terminals to two different things, or to different parts of one thing.

(10). Arrange Abel's fuses between gas and water pipes, between pieces of wire gauze and gaspipe, between hot-water pipe and a bit of sheet metal, between the lightning-conductor and a 6in. metal sphere on long glass stem, between two large insulated bodies, between the gas-bracket of another room and an empty Leyden jar; in short, in almost any place, likely or unlikely. Then take a few strong discharges through the thick copper rod with end well earthed, and the fuses will pop off, some at one discharge, some at another. Very visible sparks can sometimes be seen passing into the fuses, if they be not closely connected, without exploding them. A certain energy of spark is necessary to ignite the composition: much more than is sufficient to excite the retina.

* This easy and striking experiment I stupidly omitted to show at the meeting.

Lightning Protectors.

33. Now let me say a word about the possibility of protecting telegraph and other instruments from damage by lightning currents which may have entered the aerial lines. There is, indeed, no guarantee that burying wires beneath a pavement, or even beneath water, will effectually secure them from lightning disturbance, as I have now fully illustrated, but certainly overhead wires are more exposed. The ordinary and well-known form of lightning protecting arrangement is to attach a pair of plates, or a double set of points, or a pair of points in a vacuum, or some other small air space, as a shunt to the instrument or coil of wire to be protected. Here are arrangements of the kind. Now it is perfectly easy to see that the protection such things afford is of the most utterly imperfect kind. Take a coil of tangled silk-covered wire, or any other coil that you do not mind damaging, and attach it as a shunt to one of these protectors. On discharging a jar through it, the insulation of the coil is pierced in heaps of places; or one may use a short fine wire, and see it deflagrated by the branch discharge.

34. It may be said that my air space is too wide. Very well, then, abolish it altogether. Bring the plates of your protector into direct metallic contact. By so doing, the coil is, indeed, shunted out of the circuit, and if it were a telegraph instrument no signal could be given, for no appreciable fraction of the current takes that route; but with a Leyden-jar flash it is otherwise. Although the plates of the protector are in contact, soldered together if one pleases, and led up to by stout wire or rod, a branch flash still breaks through the insulation of our wire tangle, or deflagrates our little bit of thin wire.

35. It will be said the joints are bad. Well, then, do without joints; take a stout rod of electrolytic copper bent in an arc, say, 2ft. long, and, bridging it across with the wire tangle, discharge a jar round it. Still a portion takes the thin wire, even though it offer a path yards in length. Take a straight bar of copper an inch thick, and arrange an invisibly fine Wollaston wire of greater length as a tapping circuit. Some of the discharge shall leave the bar, and spark across a minute air gap at each end, in order to make use of the hair-like platinum wire. Go further still than this. Connect a coil of thin-covered wire *by one end only* to a wire conveying a discharge, standing the reel upon a block of paraffin or other good insulator, and connect the other end to any little thing of any capacity at all—say a bullet lying on the block of paraffin: you can see sparkings through the insulation of the wire on the reel at every discharge. These experiments render manifest the hopelessness of any simple shunt arrangement as a lightning protector.

36. The easiest mode of exhibiting the essentials of these experiments, one that can be tried by anyone possessing a Leyden jar, a pair of discharging tongs, and a yard or two of fine silk-covered wire, is to hang a tangle of the wire loosely on to the tongs, not necessarily making any sort of good contact, and then use them to discharge a jar in the very ordinary way. Some of the flash will take the thin wire, and will spark through the insulation at a number of points.

37. It may be very well objected to me that it is pretty useless if I only point out the imperfection of present methods, and offer no suggestion as to a proper lightning protector. Well, this struck me, too, and the result is that I have devised and made what I think I may call an absolutely perfect protector—one into which great flashes may be sent, and yet the galvanometer or instrument intended to be protected shall not wink nor shall the slightest palpable or visible disturbance be discernible, notwithstanding that complete metallic contact is maintained all the time, and not a trace of the signalling or useful current wasted. The thing seems so good that I am making it the subject of a patent, and you will, therefore, pardon me for saying no more about it just yet.

38. The next part of this paper is largely controversial. I do not take much pleasure in this portion, and wish it were unnecessary. But it is a purely impersonal controversy; and so long as the old-fashioned views are in existence, one way of arriving at the truth is to try and thrash them out of existence. If there is any real vitality in them, the attack will fail. It will be well believed that I have no feeling of hostility to the Lightning-Rod Conference, when my best scientific friend, Prof. Carey Foster, was one of its members. Had I been one myself, I no doubt should at that time have signed the very documents which now, in a few places, I criticise. Had I, indeed, so signed, I would abuse what I now see to be its erroneous portions with still more vigour than I now permit myself to employ.

Summary of Points of Difference and Controversy.

39. It may be convenient here to summarise a few of the points wherein the doctrines which I advocate differ from the

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views held by the older electricians. And the summary will give me an opportunity of emphasising the incorrectness of the older views in many instances. I quote a few statements prefixed by capital letters from an abstract I made for the *Electrician* after the Bath meeting of the British Association.

A. Rods, as at present constructed, though frequently successful, may and do sometimes fail, even though their earth is thoroughly good, the reason being that they offer to a flash a much greater obstruction—a much worse path—than is usually supposed: an obstruction to be reckoned in hundreds or thousands of ohms, even for a very thick copper rod. N.B.—This is not resistance proper, but impedance.

I may be permitted here to repudiate the doctrine which has several times been attributed to me since the Bath meeting, that it is safest to be without lightning-conductors altogether. The long experience of persons learned in this art is by no means to be despised, and until an agreement as to improvements has been arrived at, the safest plan for ordinary persons is to adhere to existing practice. Nevertheless, that conductors sometimes fail, is as certain as that they often succeed. My statement is that customary arrangements are not perfect, and are susceptible of improvement. The statement of the Lightning-Rod Conference is that "there is no authentic case on record where a properly constructed conductor failed to do its duty." Mr. Preece calls the statement "most decisive." It is certainly decided, and in the light of other matter contained in the same red covers I assert it to be in its natural and intended signification decidedly false. The only signification which makes it true makes it also senseless; as if one should record the statement that white things are white. In my Society of Arts lectures, I said nothing against the report of the Lightning Rod Conference, because the work done by that body, in collecting information, abstracting papers, and recording instances, was obviously very valuable, and much of the report itself is correct; while as for the occasional rash statements in that document I imagined the signatories would wish them to sink into oblivion in silence. But Mr. Preece has revivified them, and conspicuously made himself afresh responsible for them;* accordingly I now extract one or two more sufficiently dogmatic and unfortunate statements from the same source.

"A man may with perfect impunity clasp a copper rod an inch in diameter, the bottom of which is well connected with moist earth, while the top of it receives a violent flash of lightning."

"If all these conditions be fulfilled; if the point be high enough to be the most salient feature of the building, no matter from what direction the storm may come, be of ample dimensions, and in thoroughly perfect electrical connection with the earth, the edifice, with all it contains, will be safe, and the conductor might even be surrounded by gunpowder in the heaviest storm without risk or danger."

To adhere to such views as these now, with tenacity sufficient to cause them to be promulgated as authoritative scientific statements would be, in my opinion, little less than criminal.

"All accidents may be said to be due to a neglect of these simple elementary principles." Certainly this "may be said," because it already has been said over and over again; but it cannot be said with truth.

Whenever an accident happens, a believer in the modern exponents of the Lightning Rod Conference who could not point out a flaw, or a bad joint, or a bad earth, or a possible flaw, or a possible bad joint, or a possible bad earth, would feel himself disgraced as a practical man. An instance occurred in quite a recent number of *Nature*. The writer of "Electrical Notes" records that a number of fish had been killed in a pond into which the earth end of a conductor had been led, and concludes with the ejaculation, "When will people learn to make proper earth connections?" I select this instance as typical of the extraordinarily contradictory advice often bestowed on that long-suffering body the British public. Before an accident, the pond would be pointed out as an excellent earth, as indeed it most likely was. After the slaughter of the fish, the erector of conductor is impersonally ridiculed for having utilised it. So with any struck building. After an accident defects must be forthcoming, because else there would be "an authentic case on record where a properly constructed conductor failed to do its duty," which *ex hypothesi* is absurd and impossible; therefore it was not constructed in accordance with the directions of the Lightning Rod Conference, therefore it was defective. *Q.E.D.*

B. When a Leyden jar is charged it corresponds to a bent spring, and its discharge corresponds to the release of the spring. Its discharge current alternates, therefore, in the same way and for much the same reason as a twitched reed or tuning-fork vibrates. The vibrations decay in either case because of frictional heat production, and because of the emission of waves into the surrounding medium. A single spark of a Leyden jar, examined in an exceedingly fast revolving mirror, is visibly drawn out into a close succession of oppositely-directed discharges, although its whole duration is so excessively minute. It is very likely that this statement will now no longer be denied. So I pass to the next.

* Saying at Bath, as a prelude to a quotation from the report, "The report itself is most decisive and most important; there is a true ring about it—the ring of men who knew what they had done, and what they were writing about."

C. A lightning flash is a spark between cloud and earth, which are two oppositely electrified flat surfaces, and the flash corresponds, therefore, to the internal sparking between the two plates of a great air condenser. All the conditions which apply to a Leyden jar under these circumstances are liable to be true for lightning. Sometimes the resistance met with, either in the cloud itself or in the discharger, may be so great that the spark ceases to be oscillatory, and degenerates into a fizz or rapid leak; but there can be no guarantee that it shall always take this easily manageable form; and it is necessary in erecting protectors to be prepared for the worst and most dangerous form of sudden discharge. The apparent duration of a lightning flash is due to its frequently multiple character, and indicates successive discharges, not one long-drawn-out one. Nothing that lightning has been found to do disproves its oscillatory character, because Leyden jar discharges, which are certainly oscillatory, can do precisely the same. This was in answer to Mr. Preece's contention that lightning could not be oscillatory, because it magnetised steel bars and deflected ships' compasses. The next is an antidote to the continually made statement that the one thing needful for an efficient lightning-conductor is conductivity.

D. Although some conductivity is necessary for a lightning-conductor, its amount is of far less consequence than might be expected. The obstruction met with by an alternating or rapidly varying discharge depends much more on electromagnetic inertia or self-induction than upon common resistance. So much obstruction is due to this inertia, that a trifle more or less of frictional resistance, in addition, matters practically not at all. It is very desirable to have a good and deep earth in order to protect foundations and gas and water mains from damage, and in order to keep total impedance as low as possible. I find it sometimes thought that I have argued against the need of a good earth. This is not so. I have argued against the exclusive and exaggerated attention that has been paid to this need.

In opposition to the following statements, *e*, *f*, *g*, *h*, *i*, the substance of which may be considered as hitherto orthodox, I make the statements subsequent, labelled, E, F, G, H, I:

e. No danger is to be feared from a lightning-conductor if only it be well earthed, and be sufficiently massive not to be melted by a discharge. All masses of metal should be connected to it, that they may be electrically drained to earth.

f. The shape of the sectional area of a conductor is quite immaterial; its carrying power has nothing to do with extent of surface; nothing matters in the rod itself but sectional area or weight per foot run, and conductivity.

g. Points, if sharp, should constitute so great a protection that violent flashes to them ought never to occur.

h. Lightning-conductors, if frequently tested for continuity and low resistance by ordinary galvanic currents, are bound to carry off any charge likely to strike them, and are absolutely to be depended upon. The easiest path protects all other possible paths.

i. A certain space contiguous to a lightning-rod is completely protected by it, so that if the rod be raised high enough a building in this protected region is perfectly safe.

These statements I say are erroneous. The following I believe to be correct:

E. The obstruction offered by a lightning-rod to a discharge being so great, and the current passing through it at the instant of a flash being enormous, a very high difference of potential exists between every point of the conductor and the earth, however well the two are connected; hence, the neighbourhood of a lightning-conductor is always dangerous during a storm, and great circumspection must be exercised as to what metallic conductors are wittingly or unwittingly brought near or into contact with it. When a building is struck, the oscillations and surgings all through its neighbourhood are so violent that every piece of metal is liable to give off sparks, and gas may be lighted even in neighbouring houses. If one end of a rain-water gutter is attached to a struck lightning-conductor, the other end is almost certain to spit off a long spark, unless it also is metallically connected. Electric charges splash about in a struck mass of metal, as does the sea during an earthquake or when a mountain top drops into it.* Even a small spark near combustible substances is to be dreaded.

F. The electrical disturbance is conveyed to a conductor through the ether or space surrounding it; expressed more simply, lightning currents make use of the periphery of a conductor only, and so the more surface it exposes the better. Better than a single rod or tape is a number of separate lengths of wire, each thick enough not to be easily melted, and well separated so as not to interfere with each other by mutual induction. The liability of rods to be melted by a flash can be easily over-estimated. A rod usually fails by reason of its

* *See* the Report of the Krakatoa Committee.

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inertia-like obstruction, and consequent inability to carry off the charge without spittings and side flashes; it very seldom fails by reason of being melted. In cases where a thin wire has got melted, the energy has been largely dissipated in the effort, and it has acted as an efficient protector; though, of course, for that time only. Large sectional area offers very little advantage over moderately small sectional area, such as No. 5 B.W.G.

G. Points, if numerous enough, serve a very useful purpose in neutralising the charge of a thunder cloud hovering over them, and thus often prevent a flash; but there are occasions, easily imitated in the laboratory, when they are of no avail: for instance, when one upper cloud sparks into a lower one, which then suddenly overflows to earth. In the case of these sudden rushes, there is no time for a path to be prepared by induction, no time for points to exert any protective influence, and points then get struck by a violent flash just as if they were knobs. Discharges of this kind are the only ones likely to occur during a violent shower, because all leisurely effects would be neutralised by the rain drops better than by an infinitude of points.

H. The path chosen by a galvanic current is no secure indication of the course which will be taken by a lightning flash. The course of a trickle down a hillside does not determine the path of an avalanche. Lightning will not select the easiest path alone; it can distribute itself among any number of possible paths, and can make paths for itself. Ordinary testing of conductors is therefore no guarantee of safety, and may be misleading. At the same time it is quite right to have some system of testing and of inspection, else rust and building alterations may render any protector useless.

I. There is no space near a rod which can be definitely styled an area of protection, for it is possible to receive violent sparks or shocks from the conductor itself; not to speak of the innumerable secondary discharges which, by reason of electro-kinetic momentum and induction, and by reason of electromagnetic waves of the curious recently discovered effect of the ultra-violet light of a spark, are liable to occur as secondary effects in the wake of the main flash.

(To be continued.)

BOARD OF TRADE ENQUIRY.

WEDNESDAY, APRIL 17.

Major Marindin, C.M.G., R.E., on behalf of the Board of Trade, resumed the enquiry at the Westminster Town Hall, for the purpose of hearing, on the part of a number of electric lighting corporations, their provisional orders to erect and maintain electric lines and works, and to supply electricity within certain areas in the metropolis and elsewhere, and the objections raised thereto by other companies and corporate bodies.

Mr. Henry Blake (chief clerk to the Commissioners of Sewers) was examined by Mr. Russell Griffiths, and gave evidence as to the amount which had been expended on electric lighting in the City from 1878 to 1888 inclusive, the total sum having been £12,519. He had got in his custody the tenders made by the various companies for the electric lighting. In some of those tenders there were certain conditions as to the private lighting of the City. He had seen the streets of the City opened from time to time at various places. There were a great many pipes of various kinds underneath. Supposing two companies were allowed to compete within the area of the City, laying down mains in competition with one another, whether there would be room for them would depend a great deal on the depth they wanted to go to, and whether it was below the footways or the roadways. There would be a great difficulty in going below the gaspipes.

Cross-examined by Mr. Pember, he said that he knew nothing in the Electric Lighting Acts which excepted the City of London from the general operations of the Acts. The Commissioners practically paid small attention to the question of private lighting except that they were desirous of giving the public the benefit of the light under guarded conditions. He did not think that those conditions were in conflict with the Electric Lighting Acts of 1882 and 1888. The Commissioners had always gone on the principle that they had a right to deal with the pavements as should seem best for the good of the public. The power of corporations to purchase electric light companies' interests up at the end of 42 years constituted a material difference in their position from that of a gas company which had got its work for ever. They considered that in all cases they were giving a great boon to contractors by giving a wayleave for private lighting.

Cross-examined by Mr. Lyttleton, he said he did not know that a great many applications had been received by the Metropolitan Company from the City. If the Commissioners were satisfied with the license or the provisional order, he did not know that they would oppose any public lighting company going into the City. There were only two applications for provisional orders which the Commissioners were opposing now. They must be satisfied with the provisional orders before giving their consent.

Mr. Wm. Henry Preece, electrician to the Post Office, was called and examined by Mr. Griffiths. He said that he had advised the Commissioners of Sewers in electric lighting since 1882. He had been consulted since that year, but he had been associated with electric lighting since 1878. The residential number of persons within the City was 261,061, a number greatly increased in the day time. There would be a great many places that would require to be lighted during the day as well as during the night, as every available place that could be used for offices was let. That made the use of artificial light in the City during the day time a greater necessity than it was in other places. It was not only a necessity, but a great value. The estimated number of gas lamps in the City was 622,000 used for ordinary purposes. The ordinary average was 5ft. per hour per gas burner. The number of public gas lamps lighted in the City was 3,136, lighted at a present cost to the Commissioners of £10,530. The time during which light would be required for private purposes would be up to about seven. There were printing works and other places going on all night, so that there would be a great deal of light wanted during the night as well as during the day. The office hours in the City might be fairly taken up to seven, although there were a great many closed at five and six.

Mr. Pember: And some stay later.

Witness: Yes.

By Mr. Griffiths: It was an extremely difficult thing to form anything like an accurate estimate of the number of hours of lighting a place like the City, and the only illustration he could get to draw any conclusion from was the central station of New York, started by the Edison Company in the neighbourhood of Wall-street, somewhat similar to the district of the City, and when he was in America in 1884 he took a great deal of pains to arrive at a fair conclusion as to the average number of hours per lamp per day, and it came out at 2·4 hours per day. That was 876 hours per annum. That lighting was for the City purposes—offices, lighting, restaurants, and places of that kind—a fair average for places like the City for private lighting. The latitude of New York was 41, that of London 52, which would make an hour's difference in the daily average of the length of lighting in London. He doubted very much whether it was fair to draw a comparison between the private lighting of a business quarter like the City and the private lighting of a district like Kensington or Wimbledon. Of course, in a business place such as a bank, for instance, or a club, nearly all the lights were alight at once, but in a private house in the suburbs there would be a number of lamps in bedrooms which would be only used for a very short time—when the occupants were going to bed. One sitting-room might be occupied at one time, and another at another time, so that the average hours of burning a lamp in a private house was no criterion of what it would be in a place of business. He had heard the evidence of Mr. Crompton, who put the apex of the curve of light at seven o'clock, while he thought the principal demand was from five to seven. If a company supplied largely the residential part, and the shops and the theatres in the West End, he thought if they attempted to supply the City at the same time in the four winter months they would overlap very much. The consequence of that would depend very much upon the arrangement of their plant in ratio to the several demands. If they started with too small a plant for the ratio of the demand in the City, he thought their supply would rather diminish. If the electric light were to be supplied by running machinery without any storage, there would be great difficulty in meeting the double demand of the City and West End, unless additional machinery were provided. There was no question that the effect of running machinery light was that it ran very uneconomically. There were 46 miles of streets in the City including courts and alleys, and he estimated that the number of public lamps that would be required would be 500 of what were called 500 watt arc lamps—they varied, of course, very much—also 1,000 glow lamps of 25 to 32 c.p. Taking the estimate that he had given for private lighting at 622,000 gas lamps, he thought they might fairly assume, in competition that must take place between electricity and gas, that they would get a third of that—say, 210,000 glow lamps—in the City, or 70,000 for each of the three districts. The latter would be 10 c.p. lamps. The Post Office, which was partially lighted by electricity, had its own installation and machinery, which were put up under his superintendence. The cost of lighting the Post Office per unit of the Electric Lighting Act was 3½d.—the Board of Trade unit. They used Willans and Robinson's engines, which were not the most economical, and if they were replaced by engines of the present day he thought the price could be reduced to 2½d. per unit. There were in the City a great number of private installations supplying light to institutions. He had considered the scheme proposed by the London Electric Supply Corporation for the transmission of their high-tension current from Deptford to London, and he considered it a gigantic experiment. The grounds on which he formed that opinion generally were these—that he was a decided advocate for the distribution of electricity over extended areas by means of alternating currents and the transformer system, and he considered that the question of concentrating all their eggs in one basket, as the London Electric Supply Corporation had at Deptford, or distributing their central stations over the metropolis as the other companies proposed to do, was simply a commercial question of pounds, shillings, and pence. There had been ample evidence pro and con, and if a balance-sheet were struck between those reasons he thought that it would be found that they balanced each other very fairly; that there was almost as much to be said in favour of one large station down the river as there was in favour of several stations scattered over a district. But his strong objection to the scheme of the London Electric Supply Corporation was not a question of their central station, for he believed that had been perfectly worked out, but it was the connection between London and Deptford by means of their mains. The question did not seem to him to have been at all solved by Mr. Ferranti, and he regarded the proposals, as submitted to that tribunal, as very objectionable indeed. He thought that the form of main proposed by the London Electric Supply Corporation was not in consonance at all with the rest of their scheme, and it was a very weak point, requiring further and more mature consideration. He thought it was quite practicable to have a dynamo driven by 5,000 or 10,000 h.p., and it was perfectly practicable to make steam-engines and dynamos that would

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convert 10,000 or 20,000 h.p. into the form of energy called electricity, but the difficulty he was now contending for was that of transporting the converted energy from Deptford to London. He anticipated difficulties of insulation of joints and difficulties of disturbance to contiguous telephones and telegraphs. He had not seen any motor to which they could supply all the energy produced by the alternating system. There were two or three spoken of as existing, but they had not been produced yet. One was called the Telsa motor, invented in America, but it was not in the market. There were motors in the market for using the energy supplied by the direct system. He thought there would be a large demand within the City for motive power supplied by electricity, which would certainly, during the day, be a remunerative source of income to any company. He personally considered the sub-division of the City into three districts. The main reason that controlled the Commissioners of Sewers in deciding upon that, he believed—and it certainly guided him in recommending the division of the City into that number of districts—was that they could give in the first place the public the benefit of competition, while the authorities themselves would be relieved from the very greatest inconvenience of competition—that was by having their streets cut up by rival companies. The main streets were at present choked up with pipes. The Post Office, for example, down Cheapside had 15 to 20 pipes of their own, and he did not think it would be possible at the present moment to lay a six inch main down that thoroughfare. There was one objection to competition, and it was this, that if they had two companies through one district they would require double mains, double plant, and double capital. If the favours of the public were equally bestowed, those companies only got half the revenue each, and the result was that sooner or later such competition led to amalgamation, which generally led to enhanced prices to the public, who had to pay in the end. They therefore felt it would be much better if competition could be prevented in any of those districts. On the other hand, there was no doubt that competition secured splendid services—or rather the fear of competition. As regarded danger to persons from the mains from Deptford, he thought that no more effective mode could be suggested than that by Mr. Ferranti. If the outside conductors were buried in earth, or in contact with it, he did not think that any person would be liable under ordinary circumstances to get a shock, but the difficulty would be that the telegraphs would suffer. If the main between Deptford and London formed a curve, there would be conduction through the earth—the equality between the two currents upon which the security of telegraphs depend would be broken. His opinion was that with the outside to earth all the telephones in London would be affected with a pressure of 10,000 volts in main as designed by Mr. Ferranti. There was not a single telephone in London that would not be disturbed—so much, perhaps, as to prevent speech—by the alternating currents from Deptford. Telegraphic and telephonic wires all centred in the City, and were principally above ground, some being below. The maximum price proposed by the electric lighting orders was 8d., he believed. He anticipated in the progress of electrical knowledge and science that electrical energy might be produced at a cheaper rate than now. They were in a regular wave of progress, tending to economy in production.

Cross-examined by Mr. Pember: The disturbance set up in the telephone and telegraph wires to which he referred depended on there being a curve between London and Deptford; but if they could get an absolutely straight line that electrostatic induction would not be set up. Earth conduction would be effected. There would, however, be a considerable disturbance even if they had a straight line from London to Deptford. He had no doubt whatever that a cable carrying the London Electric Supply Corporation's current from Deptford to London could be made which would get rid of the Post Office objection. When that was done, any objection he had seen to the company's scheme vanished, and ensured safety to the public. He had not the slightest doubt that there would not be any difficulty in finding a proper motor which could be adapted to the alternating system. Leaving out of the question that the Board of Trade undertook safety to life, and the Post Office safety to telegraphs, he saw no other objection to the system. He did not think that in the case of electric lighting under the provisional orders competition could lead to amalgamation. If he were acting as an engineer to an electrical company like the London Electric Supply Corporation, he would advise them to tender on the basis of being ousted in 21 years, having all their undertaking bought up, provided it was by agreement with arbitration.

Cross-examined by Mr. Lyttleton, he said that there would be a difficulty in supplying the City and the West End at the same time. He did not know that a canvass had been made of the City showing a demand for not more than 60,000 lights. He spoke as the technical adviser of the City, and approved of the specification which h d been drawn up, and upon which tenders were asked. He thought it would be impossible to lay a main in Cheapside. The conditions had very largely altered since Mr. Siemens had lighted parts of the City. The Post Office alone had quite doubled the number of their pipes there.

Re-examined by Mr. Griffiths, who asked whether the 3½d. per unit of production included working expenses, the **Witness** replied that it did.

Major Marindin: I understood that nothing is included for capital charges, rent charges, or distribution.

Mr. Griffiths: No.

The **Witness**: That is so, and no depreciation.

By Mr. Griffiths: He knew that experiments were being made as to the insulation of those rigid mains referred to with regard to the outer sheathing. The result was merely a question of weeks. They had not contemplated in those experiments the reduction of voltage. They were dealing with a main carrying 10,000 volts. He thought, as an electrician, that some form of insulation would be found for such a main, and with Mr. Ferranti's precautions the dangers to the individual would be reduced to a minimum.

Examined by Major Cardew, he said that it was the case that, assuming the proposed main to be earthed at Deptford, and also to be earthed at the distant end, the inequality in the two conductors thus produced would cause an interference with telephones from current inductions. In addition to that there would be a certain interference with telephones from electrostatic induction, which was a different thing. But as long as the insulation was perfect, and if the earth could be kept to the generating point, there was no reason why there should be any current inductive effect.

Mr. Robert Hammond, managing director of the House-to-House Electric Lighting was Company, called and examined by Mr. Shiress Will: He said he had been engaged in the business for some years. Their nominal capital was £350,000, of which £41,000 had been subscribed. He anticipated no difficulty in getting the whole of their capital subscribed if the powers of the provisional order were granted. His company was not bound to any system. That actually in use was the high-tension alternating-current converter system, of which he had had six or seven years' experience. He was distinctly in favour of districting, and had been from the very beginning of the industry. He thought that the effect of competition between two or three companies in one area would be, although at first favourable to the consumer, at last disastrous, as the company left in possession of an area was able to obtain capital much more readily. There was much more inducement to invest capital if a district belonged to one company, and he thought that sufficient guarantees could be given by that company that it would not charge an excessive price. It would be to the interest of the company to do their best to serve the consumer. The fixing of a standard price would be to the interest of both the company and the consumer. He thought they could cover a district much more quickly with the converter than with the low-tension system by reason of the cheaper mains. In regard to the standard price, he might add that it was to be a price based upon a dividend. In their order they had inserted the dividend of 10 per cent., but the standard price should be based upon the payment of a dividend of 10 per cent., and they would have the power of increasing that dividend on reducing the price as the Gas Works Clauses Act provided. By placing works some distance off in the centre of the manufacturing district, it was very often possible to obtain some advantages in production, but he considered that it was absolutely destroyed by the cost of distribution.

Cross-examined by Mr. Wallace, he said that the cost of production of electricity for Board of Trade purposes at Brighton amounted to 6½d. a unit last year. It was not only the cost of the converter system, but of the Brush system. Last year was the year that they converted from one to the other. The works at Brighton were very small, and it was a marvellous thing to be able to produce electricity for that price when they were running only some 400 h.p. They proposed to charge on a sliding scale, depending upon the number of hours a man use. his light. They would allow the consumer to fix his own minimum of hours.

Mr. Wm. Lowrie, called and examined by Mr. Shiress Will, said he was engineer to the House-to-House Electric Light Company, as well as to Messrs. Hammond and Co. The voltage at which he sent out the electricity at Eastbourne was 1,900, and at Kensington 2,000. At Eastbourne their mains were copper, insulated with vulcanised indiarubber, and a small portion of them were lead covered, insulated with cotton, saturated in some compound. They used cast-iron pipes for the purpose of laying their mains in, which answered very well indeed. At Eastbourne they made tests every morning for insulation. Knowing the inadvisability of having to stop every day each circuit to test it with a Wheatstone bridge, they hit upon a small device, which showed at a glance whether the insulation was good or bad. It simply gave a proof test that there was no leakage going on. He was a very great believer in this company's system. He believed that the battery system was expensive, and he thought it offered no points of safety over an alternating system with thorough subdivision. The subdivision of plant was a very important point. One very great advantage was that as the load upon the plant increased they could put on one unit after another, and therefore keep the engines working up to a fair state of efficiency. The plant in motion at a particular time would be so arranged that whenever one portion stopped another would be ready to do the work. The portion of the plant could be cut out automatically if it was wrong before there was time given to detach it. If it did not give sufficient notice for it to be detached, it would cut itself out automatically. He also considered it a great advantage to have a subdivision of distributing mains. It was equally necessary with the subdivision of plant. The result of that was that there could be no chance of their leaving the whole of their district in darkness at any one time. In the early stages of the converter system, before it was actually known what was required to protect converters, there was always a danger of the converters burning out. With the fuse that they were using now he was quite at liberty to short circuit any converter that anyone liked to point on their circuit when the lights were running.

Cross-examined by Mr. Moulton, he said that from tests taken at Eastbourne, and also at Brighton, he found that the loss of electricity by the ordinary use of batteries was fully 30 per cent.—that was in actual practice; he did not mean laboratory tests.

Major Cardew: Is this loss of energy?

Witness: Yes; loss of energy.

Major Cardew: He asked for electricity.

Mr. Moulton: I meant loss of energy, of course.

Witness said that if the direct supply was only 100 volts, as against 2,000 volts pressure, he thought the cables would be enormously large unless the cables were made more in number, which would amount to the same thing. Under identical conditions and practice, the mains for direct supply for 100 volts would have to be 400 times the size of what the mains had to be for a high-tension 2,000 volt supply.

Major Cardew: As regards the question of burning converters, is it not the case that the danger of burning out would be

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much increased by the use of wires with inferior insulation in the house circuit?

Witness: Undoubtedly.

Major Cardew: Would you consider wires merely covered with cotton, even if saturated with paraffin, inferior wires for house service?

Witness: I should advise my company not to connect their system on at all—in fact, they would not do it with cotton-covered wire.

Prof. G. Forbes, recalled and examined by Mr. Shiress Will, said that from a general view of the condition of Kensington he should say that the alternating-current system with converters was certainly the best. It was perfectly possible to run alternating-current dynamos on the same current. That had been known for a long time. He first saw alternating-current dynamos on the same circuit at at the South Foreland Lighthouse. Prof. Adams made one actually drive the other as a motor. They synchronised perfectly. That enabled them to switch on a dynamo when the load increased without affecting the others, or to switch one out when anything went wrong with it without affecting the light in any way whatever. He had seen it done at the House-to-House station without the slightest flickering of the lights. He tested it under very severe conditions indeed, and the way the parallel working succeeded at the West Brompton station was absolutely unexceptionable. There was not the slightest doubt of its being capable of being applied in regular work. He had put it under much more severe tests than doing it under heavy loads. He had known dynamos which worked perfectly well with a heavy load, and when they were put on a light load they would run synchronously certainly, but one dynamo was always gaining a little bit over the other, a portion of the phase, so that the light had a trembling appearance. He had seen that with some dynamos working in parallel even with a light load, but when it was done with a light load there was not the slightest tremble. He might say that he put on 100 kilo-watt dynamos as low a load as about 5 h.p. without the slightest variation or trembling of the light. He then worked those two together on a single lamp, only one lamp being on circuit, and it was just barely possible to see the flicker. They could just occasionally see a little trembling in the light with only some single light on those two dynamos. He carried out the experiment himself.

THURSDAY, APRIL 18.

Prof. W. Crookes, called and examined by Mr. Wallace, said he was chairman of the Notting Hill Electric Lighting Company, and that his house had been lighted by a private installation for seven or eight years. His friends had combined to establish a small company to introduce the electric light into the neighbourhood. They had raised only a small amount of capital by way of preliminary expenses, and had not made any effort to get more from the public. The nominal amount of the capital of the company was £100,000. His company were before the Vestry of St. Mary Abbotts and Kensington, with other companies, for about 12 months. The company had been floated according to the form prescribed by law.

Mr. Wallace then opened his case for the Kensington Court and Kensington and Knightsbridge Electric Light Companies, and in the course of his address said that the Kensington and Knightsbridge Company had been in existence for a year and a half, having taken over the Kensington Court Electric Light Company. The two companies now asked practically for the same area. The Kensington Court Company was still in existence, but it was the same company as the Kensington and Knightsbridge Company, which arose in this way; the Kensington Court Company were in possession of the licenses granted by the Board of Trade, and the Kensington and Knightsbridge Company taking over the Kensington Court Company thought it advisable to apply to the Board of Trade in the name of both companies, in case there should be any technical difficulty in transferring the property from one company to the other. They had two stations, one situated at Kensington Court and the other in Chapel-street, on the north side of Brompton-road. He might say that if the inspector would cast his eye over the Chelsea map he would see that, although the area looked rather large, it really was not more than one square mile. In opening his case, he wished to say that they had been very much indebted to Mr. Crompton and his firm for the very great attention that they had given to the development of electric lighting in the district in which they had been working for the past three years. Another gentleman that he wished to refer to was Mr. Metcalfe, who, from the very inception of the Kensington and Knightsbridge Company, had been of very great assistance to them, because they had not been like the other companies, who were promoting orders and acting in a manner which they would not have been allowed to do provided they had been working under provisional orders. His company had been acting according to the provisions of the Board of Trade, and in their long negotiations with that body Mr. Metcalfe had been of the greatest service to the company. He did not wish in any way to go over the ground that had been traversed so frequently during the course of the enquiry by the other promoters, but he thought there was a slight difference between the policy which the Kensington and Knightsbridge Company advocated, and that promoted by the other schemes. They might divide the promoters into three classes. There were those who desired to have concurrent powers over the same area; there were those who, in the second place, believed in districting, and that the capital of the undertaking should be raised as far as possible within the district itself, and the stations should be situated close to the area of supply. That was the policy that the Kensington and Knightsbridge Company advocated—that the residents in the district should find the capital necessary to carry on the work, and that the district should be lighted from stations in the immediate vicinity. In saying that it would be seen that there was a difference between them and the other promoters who had advocated a series of stations apart from one another, and which, according to the experience of the Kensington and Knightsbridge Company was, perhaps, unwarranted—that was to say, the other promoters proposed to make generating stations far too large for the district in which they carried on their works. With regard to the concurrent powers, he thought it was necessary for him to mention that in his company's district they had streets very similar to those that had been spoken of by the local authorities for the Strand, and the various other witnesses that had been cross-examined at the enquiry. In High-street, Kensington, they had a great thoroughfare where the traffic was, to a very great extent, congested, and there was the same kind of mains under it as they found in the Strand and other places, such as gas, water, hydraulic, telephone, and telegraph mains, and it would be a very serious matter to his company if the mains of other companies were allowed to pass through the same conduit because his company's mains were not insulated, being bare copper strips. Therefore, they very much objected to have rival companies in the area. He believed that districting would be the best plan, for it seemed to him if rival companies were to be in the same district the very streets that they would make for would be those where the traffic was congested, because there were more shops and such places to be lighted, and such places would form the battle-ground between them. As to the result of competition, Mr. Moulton had put the matter much better than he could do. It would not do to allow those companies advocating districting to be interfered with by another company, such as the Metropolitan, which, according to its proposals, would interfere with the Kensington and Knightsbridge position of the Knightsbridge Company's district, and in the event of failure nobody would be hereafter able to judge in any case what the cause of it was. At Kensington Court they used Babcock's boiler, Willans' engines, and Crompton's dynamos and batteries, the latter being used for giving a limited supply of electricity in the case of a breakdown in their plant. Coming to the question of smoke nuisance, his company had got over the difficulty by using Welsh coal, whilst as regarded vibration, they found from experience that no sensible effect was experienced. He thought that when the inspector visited their works he would find that there was no danger on the score of vibration. As to safety, he ventured to say that his company occupied the best position. As to the coal-carts' nuisance the total quantity of coal that would be used would be 16 tons a day, which could be conveyed in eight carts, which could not in any way interfere with the traffic.

Mr. R. S. Erskine (secretary to the Kensington and Knightsbridge Company) was then called and examined by Mr. Wallace, and said that the company was started in 1886 with a capital of £10,000. It was formed with the intention of lighting Kensington Court. The Knightsbridge portion of the license was obtained in 1883. A great portion of the district was already covered by license. All the money had been found by the directors, none by the public. £57,000 had now been paid up. About £75,000 more was promised, which would be available as required. Mr. Wallace's opening speech was a general description of the works without going into details. The only competitor they had in their district was the Metropolitan Company, which had done nothing there up to the present time in the way of practical work. There had been a considerable demand for the light in the district. They had promised to begin to supply light by the middle of May under the 1888 license. There had never been any nuisance at their two stations which they had not been able to obviate in a day or two. Although no dividend had been paid, the company was being worked at a profit.

Cross-examined by Mr. C. A. Cripps, **Witness** said that the actual capital expended was within two or three thousand pounds of what had been paid up. They had never a large balance at the bank, as the amount paid up was immediately spent on plant and mains. Their district would be supplied by a circuit connected with batteries at a central station and outlying stations in the centre of the district. The sectional area of their largest distributing mains was over half an inch. The most of them were between ¼in. and ½in. in sectional area.

Mr. Wallace afterwards briefly opened his case on behalf of the Westminster Company, pointing out that the company had already established itself at Victoria-mansions, where it had a site possessed by a director of the company, and where they had placed plant from which they would be able to supply 5,000 lights in the neighbourhood. The only difficulty the company felt was that of supplying the district of Mayfair, which would be a considerable distance from their proposed station.

CITY NOTES.

Direct Spanish Telegraph Company.—The receipts of this Company for April were £1,867, against £1,800.

Change of Address.—The Monte Video Telephone Company, Limited, have removed to 25, Abchurch-lane, E.C.

South of England Telephone Company, Limited.—This Company have declared a dividend of 6 per cent. per annum on the preference shares for the half-year ending April 30.

West India and Panama Telegraph Company.—The receipts for the half-month ended April 30 were £3,410, against £3,337. The January receipts, estimated at £5,151, realised £5,354.

London Platino-Brazilian Telegraph Company, Limited.—A meeting of this Company was held last week at the offices, 19, Great Winchester-street, E.C., to which representatives of the Press were refused admittance.

Western and Brazilian Telegraph Company, Limited.—The Directors of this Company, after placing £7,000 to renewal fund, £6,400 to debenture redemption fund, and writing off the rebate on issue of debentures—viz., £26,100, recommend a dividend of 9s. per share, tax free, making with the interim a total distribution for the past year of 5 per cent., as compared with 4¼ per cent. for 1887.

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NEW COMPANIES REGISTERED.

Pontypridd Electric Lighting Company, Limited.—Registered by Drake, Driver and Leaver, Limited, with a capital of £10,000 in £5 shares. Object: to generate and supply electricity, electric light, and electric power in Pontypridd and Ystradgfodwg for public or private purposes. The first subscribers are:

	Shares.
H. Hopkins, Fairlawn, Pontypridd	1
R. Evans, Pontypridd	1
W. Williams, Market-square, Pontypridd	1
D. Evans, Taff-street, Pontypridd	1
D. Cull, Mill-street, Pontypridd	1
W. Merchant, Pontypridd	1
W. Morgan, Pontypridd	1

Registered without articles of association, and, consequently, the regulations of table A in the first schedule of the Companies Act, 1862, apply.

Jensen Electric Manufacturing Company, Limited.—Registered by Batten, Proffitt, and Scott, 32, Great George-street, S.W., with a capital of £80,000 in £5 shares. Object: to carry out an agreement, dated April 26th, made between Clifton Shield and C. F. Helder of the one part, and J. M. M'Donnell, as trustee on behalf of the Company, of the other part. The first subscribers are:

	Shares.
J. Proffitt, 32, Great George-street, S.W.	1
F. Wall, 16, Temperley-road, Balham	1
V. Lambley, 35, Crondrel-road, Fulham	1
J. Young, 54, Cheriton-square, Tooting	1
F. Galsworthy, 8, Smith-square, S.W.	1
A. Scott, 32, Great George-street, S.W.	1
C. Jones, 32, Great George-street, S.W.	1

The regulations of table A in the first schedule of the Companies Act, 1862, with slight modifications, apply.

Electric Tramcar Syndicate, Limited.—Registered by Davidson and Morris, 40 and 42, Queen Victoria-street, E.C., with a capital of £20,000 in £10 shares. Object: to acquire the letters patent granted to A. J. Jarman for an invention for "improvements in the construction of electromotors for the propulsion of tramcars, electric locomotives, vehicles and other purposes." The first subscribers are:

	Shares.
H. J. Hemmerde, 15, Lee-park, Blackheath	50
J. Hemmerde, 10, Elliot-place, Blackheath	50
J. Muirhead, 23, Regency-street, S.W.	10
H. Archer, 31, Lombard-street, E.C.	1
A. Hemmerde, 10, Elliot-place, Blackheath	10
Captain La Feuvre, 235, High-road, Lee	1
W. Harris, 136, Drayton-park, Highbury	1

The number of Directors shall not be less than three nor more than seven. The first are J. Muirhead, P. E. Lentilhac, and H. J. Hemmerde; H. Archer, if willing to act, shall be appointed after completion of purchase. Qualification, £500 stock. Remuneration to be determined in general meeting.

PROVISIONAL PATENTS, 1889.

FEBRUARY 27.

3487A. **Improvements in means for actuating signals, switches, and gates on electric and other railways.** Robert Cooke Sayer, 11, Clyde-road, Redland, Bristol. (This application having been originally included in No. 3,487, dated 27th February, 1889, takes under Patents Rule 23, that date.)

3487B. **Improvements in means for supplying electric current to road vehicles, boats, and the like.** Robert Cooke Sayer, 11, Clyde-road, Redland, Bristol. (This application having been originally included in No. 3,487, dated 27th February, 1889, takes under Patent Rule 23, that date.)

APRIL 29.

7088. **Improvements in electric measuring instruments.** Robert Snowdon, Staveley Iron Works, Chesterfield.

7108. **Improvements in safety devices for high-voltage circuits.** Bernard Mervyn Drake and John Marshall Gorham, 2, Prince's-mansions, Victoria-street.

7127. **Improvements in or connected with the brush contacts of electric railways.** George Edward Vaughan, 57, Chancery-lane, London. (Samuel Trott, Nova Scotia.)

7129. **Improvements in arc electric lamps.** Arthur James Howes, 28, Southampton-buildings, Chancery-lane, London. (Complete specification.)

7133. **Improvements in electric meters.** Anthony Reckenzaun, 28, Southampton-buildings, Chancery-lane, London.

7138. **Improvements in and connected with electric glow lamps.** Arthur Willington Fitch, 4, South-street, Finsbury, London. (Richard Oliver Gardner Drummond, South Africa.)

APRIL 30.

7165. **Apparatus for electrical distribution of energy.** John Macintosh Mackay Munro, 136, Bothwell-street, Glasgow.

7183. **Improvements in actuating points or switches in connection with the operation of the signals.** Cuthbert Ellison Carr, 46, Lincoln's-inn-fields, London.

7198. **Improvements in the manufacture of electric arc carbons.** Walter Ernest Adeney and Llewellyn Saunderson, 24, Southampton-buildings, Chancery-lane.

7215. **Improvements in secondary batteries.** Charles Barnard Askew and James Kent Pumpelly 1, Queen Victoria-street, London. (Complete specification.)

MAY 1.

7275. **Improvements in arc lamps.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, Chancery-lane.

MAY 2.

7336. **Improvements in apparatus for electrical communication for trains and similar purposes.** Arthur Cecil Cockburn and John Nealor Cooper, 32, Gaisford-street, Kentish-town-road.

7337. **Improvements in electric winding and striking clocks.** Joseph Jacomin, 46, Southampton-buildings, Holborn. (Complete specification.)

7349. **Improvements in the methods and means of working the driving appliances on electrically propelled vehicles.** Michael Radcliffe Ward, 9, Warwick-street, Regent-street, London.

MAY 3.

7356. **Improvements in galvanic or primary batteries.** Charles Maltby-Newton, Holly Lodge, Windmill-road, Croydon. (Complete specification.)

7395. **Improvements in or relating to commuting alternating currents of electricity.** Wilfrid Swanwick Boult, 24, King's-mount, Birkenhead.

7405. **Improved means for utilising terrestrial and atmospheric electricity for the production of motive power and other purposes.** Enrique Cortes, 191, Fleet-street, London. (Rafael Zerda Bayon, South America.)

7416. **Improvements in devices and apparatus for controlling and regulating motive power for various purposes, but having especial reference to the use of electric motors for training heavy guns.** Benjamin Joseph Barnard Mills, 23, Southampton-buildings, Middlesex. (Bradley Allan Fiske, United States.)

7423. **Improved means or apparatus for driving rotary hair brushes and the like by electricity.** Herbert John Dowsing and Henry Sherley Price, 115, Cannon-street, London.

7428. **Improvements relating to electric accumulators or secondary batteries, and to the manufacture of plates or electrodes therefor.** Charles Pollak, 45, Southampton-buildings, London.

MAY 4.

7473. **Improvements in switch apparatus for electrical circuits.** Charles Ambrose McEvoy, 28, Southampton-buildings, Chancery-lane, London.

7475. **An improvement in telephonic signal apparatus.** Charles Butler Clay, 28, Southampton-buildings, Chancery-lane, London.

7499. **Improvements in the method of and means for producing low tension alternating electric currents and applying same to sundry purposes.** Edward Manville and William Leonard Madgen, 1, Queen Victoria-street, London.

7506. **Improvements in the electric lighting of railway trains.** Illius Augustus Timmis, 2, Great George-street, Westminster.

7507. **Improvements in mechanically and electrically working, repeating, and interlocking railway points and signal apparatus in conjunction with block instruments and the lighting of signal and station lamps.** Illius Augustus Timmis, 2, Great George-street, Westminster.

SPECIFICATIONS PUBLISHED

1888.

6680. **Electric railways.** Vaughan (Trott). 8d.

6907. **Storage batteries.** Immisch. 8d.

6909. **Dynamo-electric machines.** Haughton. 8d.

6961. **Automatic electric batteries.** Nussbaum. 8d.

7083. **Electric medical batteries.** Ford. 8d.

9508. **Ship telegraphing apparatus.** France and Morgan. 8d.

10107. **Casing for electrical conductors.** Snell. 8d.

1889.

3679 **Regulating electric currents.** Lake (Thomson). 8d.

4336. **Electrical switches.** Spencer (Paiste). 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	18
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply ...	5	3½
......	...	Swan United	3½	2¾
12 July	12/0	Telegraph Construction ...	12	42
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15½

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NOTES.

Sebastopol.—The Municipal Council of this town has decided to adopt the electric light. Tenders will be invited shortly for the lighting of the town.

Electricity in Churches.—The three organs in the Church of Saint-Jacques-du-Haut-Pas, at Paris, are to have an electro-pneumatic attachment, so that one organist can play the three organs simultaneously.

The Passion Play.—This play, which, as is well known, is usually given at Oberammergau, in Bavaria, is to be played this year at Brixlegg, in the Tyrol. The scenes and tableaux will be illuminated by the electric light.

Exeter.—The Exeter Electric Light Company have offered to supply tradesmen first and private residents next with their light free of charge for the first two months of the installation. The erection of the works for the central station in New North-road is making considerable progress.

Vienna.—An international company has been started in Vienna for the purpose of supplying the streets and private houses with the electric light at the least possible cost. The capital of the concern is five millions of florins, and the issue of the shares will be made by the Union Bank of Vienna.

Lighthouse Illumination.—A new committee of the Royal Society has been formed, consisting of the President (Prof. Stokes), Sir William Grove, and Lord Rayleigh. The committee are to decide whether the conclusions of the Trinity House on lighthouse illuminants are justified by the experiments.

Vestries and Telephone Wires.—At the St. George's Vestry attention was called to the overhead wires of the telephone company at Vauxhall-bridge-road. It was mentioned that the permission of the Vestry had not been asked; they had no control over them, or many of them would be pulled down.

The Institution.—At the next meeting of the Institution of Electrical Engineers, on May 23, a paper will be read by Mr. W. M. Mordey, "On Alternate Current Working," which may be expected to fully deal, amongst other things, with the principles and construction of the Mordey alternator.

Spain.—Tenders will be received up to the 20th inst. by the Minister for the Colonies at Madrid for the establish ment of three submarine cables to be laid between the islands of Luzon, Panay, Negros, and Cebu. The total length is about 207 miles, and the basis of the estimate is 1,100 pesetas (£41. 5s.) per mile.

Edison's Bamboos.—Some year and a half ago Frank McGowan was sent by Edison to the wilds of South America to find, if possible, the ideal bamboo for the incandescent lamp filaments, one which should be tough and durable. It is asserted that Mr. McGowan has succeeded in his quest, after almost incredible adventures and sufferings.

Conundrum for Young Electricians.—Given these conditions: A telegraph cable of 900 miles in length between two foreign ports A and B. The instruments at B have gone wrong, and others cannot be procured. The only instruments available are an astatic galvanometer, a shunt-box, and a battery. B has to take his test for the insulation resistance of the cable. What is B to do to obtain an approximately accurate test from his end?

Searching for Treasure.—Captain Ponsonby, who has actually trod the decks of "L'Orient," the French battleship sunk by Nelson at Aboukir, and now lying submerged in the same place, is going out with selected divers to search and attempt to recover the treasure known to be on board. A limited company has been formed to provide funds, and to take over the concession already obtained, and dynamos and lamps will be taken out to continue the search uninterruptedly by electric light.

Killed by an Electric Shock.—An extraordinary case of accidental death by electricity is reported from America. Mr. Vincent, a well-known citizen, and brother of Bishop Vincent, of the Methodist Church, being in a low state of health, conceived the idea of treating himself by electricity. Instead, however, of procuring the ordinary medical electrical appliances, he rashly interfered with the mains of one of the electric light and power companies, and received a shock which killed him as quickly and as surely as lightning.

Tender for Shanghai. — The authorities of the French Concession at Shanghai, China, are inviting tenders for the lighting of the said concession by a system which shall commend itself as best for lighting and actual cost. The contracts are to date from April 1, 1891, for a term to be decided upon for each tender. Tenders are to be sent to Shanghai before December 31, this year, and all further particulars can be obtained of the Engineer of the French Municipality at Shanghai, or of M. A. Servant, 6, Rue de Braque, Paris.

Railway Telegraphic Facilities.—Mr. Raikes, in answer to a question in the House of Commons on Monday, said that he had already stated that there were nearly 1,600 railway stations open for the transaction of telegraph business on behalf of the Post Office. Arrangements are continually being made with the railway companies to open additional stations for telegraph business where there are the necessary facilities for transacting it; and the authorities would always be glad to communicate with the companies in regard to any reasonable application for such facilities.

Electricity Not a Material.—Judge Simonton, at Harrisburg, Pennsylvania, in a suit by an electric company to avoid taxation, has decided that electricity is not a material substance. From this it follows that electric light companies are not manufacturing corporations within the meaning of the Act, and are therefore not exempt from taxation. He holds that the term "manufacturing" cannot be properly applied to any corporation not producing material substances, and neither electricity or electric light being material, the Act imposing a tax is upheld as constitutional.

New Railway Block System.—A Madras paper states that "the model of the new railway block system, invented by Mr. Wale, telegraph master, Madras, who has taken out a patent for the system, has arrived from England, where it was made by Messrs. Siemens Brothers, the electrical engineers. It was exhibited at the Central Telegraph Office on the Beach on Monday last, and was inspected by Mr. F. G. Maclean, superintendent of telegraphs, who expressed himself well pleased with the instrument. The inventor claims for his system, which is by no means complicated, several advantages over any of the block systems now in use."

Post Office Telegraphs.—A Parliamentary paper has been issued under the heading of "Additional Estimate,"

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containing an estimate of the additional amount required in the year ending March 31, 1890, to defray the expenses connected with the acquisition of the Submarine Telegraph Company's property required for the Post Office telegraph service. The amount required is £67,163, which is accounted for under the sub-heads of cables, buildings, cable ships, instruments, and stores, bonus for officers of the company not taken into the service of the State, interests, etc. The appropriation in aid, which is deducted from the gross total of £81,313, amounts to £14,150.

Thomson-Houston Lamps in Paris.—We learn from Paris that the representative of the Thomson-Houston Company in that city has secured a large proportion of the street lighting, and that the arc lamps on this famous system were started for the first time on Saturday night in the Place de la Concorde. Large contracts are also in hand for incandescent lighting, which will be carried out on the Thomson-Houston alternating system. Although Paris was the first to adopt arc lights in her streets on the Jablochkoff system, these had a very brief enjoyment of public utility, and the Thomson-Houston arc lamps are the first public electric lights that have been seen in Paris for many years.

Competition.—The Dutch Electrical Society (Harlem) invite competitive answers, to be sent in up to January 1, 1890, to the following questions: 1. Experimental or theoretical research upon known phenomena of electrodynamics and induction. 2. Experimental determination, by one or more methods, of the influence of compression in the direction of the E.M.F., and perpendicular to that direction upon the power of the specific inductor. Replies, in Roman character, may be written in Dutch, French, Latin, English, Italian, or German, and must be accompanied with a sealed envelope containing the name and address of the competitor. They must be addressed to the secretary of the society, Prof. J. Bosscha, Harlem.

The Southwark Electric Railway.—The preliminary experimental train for the London and Southwark Subway will be tried, it is expected, in about three weeks' time. Messrs. Mather and Platt, who have the work in hand, are sending down the necessary machinery and plant, and a temporary power station will be instituted for the trial of the system, somewhere between London Bridge and the first station. The experimental train will be run on the first section of the line, and it is hoped to have the matter sufficiently perfect to have a press view of the trial for the technical journals. It may be well to mention, once for all, that we are informed there is not the slightest intention of the company to run any part of the line by the ordinary cable system.

Combined Town Plants.—The Heisler Electric Light Company, of St. Louis, U.S., has entered into a contract with an Illinois electric light company for an electric light plant to supply the three towns of Ottawa, Marseilles, and Seneca, Illinois. The station will be situated at Ottawa, as the centre point of the system, from which all three of the towns will be furnished with street and commercial lights. Long-distance lighting is one of the special features of the Heisler system, and the example here given, probably the first of its kind, of several towns uniting for the supply of a long-distance series incandescent service, may be worthy of imitation where there are several small towns or villages sufficiently near and sufficiently neighbourly to co-operate in this manner.

Magnetic Viscosity.—Mr. Thomas T. P. Bruce-Warren has found that if a magnetic substance like soft iron be covered by different liquids, not only is its susceptibility modified by the permeability of the intervening medium, but there is distinct evidence of a molecular stress being produced on the medium, and which indicated itself in the case of one experiment by decided tendency of a balanced magnet to stick, as it were, when allowed to remain for a short time over the soft iron. Mr. Bruce-Warren thinks that this is due to the fact that the maximum effect of a magnet on soft iron depends on the rapidity with which the medium accommodates itself to the constrained condition necessary for the soft iron to take its greatest degree for magnetisation. He calls this "magnetic viscosity."

Westinghouse Opens the Campaign.—Westinghouse has commenced proceedings in France, where he is about to form a company with a capital of one million sterling. The company is to erect and fit up a number of works for the manufacture of plants (steam-engines, dynamos, transformers, meters, lamps, etc.) for supply to central stations. It also proposes to compete for the lighting of the Parc Monceau, the Champs-Elysées, and a section of the left bank of the Seine. A well-informed Yank, who professes to know all about it, says that Westinghouse is also awaiting the result of the Board of Trade enquiry, not that he hopes much from it, but it may make matters more difficult for him, and therefore give him a chance of showing what America can do when she is put to it. Look out, electric lighting companies.

Electric Lighting in Holborn.—At the last meeting of the Holborn District Board, Messrs. Rooper and Co. wrote asking the consent of the Board to an application to the Board of Trade for a licence to allow Gwynne's Pilsen Lighting Company to supply electricity in the district. A representative, who attended in support of the application, said that it was the only one of the electric lighting companies supplying the district that had works in Holborn. The company had taken large premises in Leather-lane, and when they were in full working order, they would not only produce a large revenue to the Board in rates, but would also bring a lot of trade. In reply to a member, the speaker said that the company was at the present moment supplying the district from their premises in the Euston-road. If the Board gave their consent, and the licence was granted by the Board of Trade, it would invest them with compulsory powers. The chairman said that there were many things to be considered in connection with this matter, so he thought the best course to adopt was to refer it to the Committee of Works for consideration and report.

The Eiffel Tower and the Spectroscope.—The Eiffel Tower may be said to have commenced its expected career of usefulness as an aid to scientific investigation in a sufficiently startling manner. According to the Paris correspondent of the *Daily News*, M. Jansen, of the Academy of Sciences, claims to have made a discovery which upsets the entire theory based on the analysis of celestial bodies by means of the spectroscope. Last Sunday the electric lamps of the Eiffel Tower were turned on the Meudon Observatory, which is 7,800 metres (four miles seven furlongs) away. He reckons that the mass of air lying in a given section of that length at the height of the tower is equal to the atmospheric mass above. M. Jansen argues from this that the number of molecules of air encountered by a beam of light sent from the Eiffel Tower to the Observa-

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tory is about the same as that met by sunlight on its way to the earth when the sun is near the zenith. He then shows that, if the analogy holds true, the belief that the sun contains oxygen is unfounded, and that if its spectrum contains the characteristic oxygen rays, this is due to the oxygen of our atmosphere. One of the fundamental theorems of spectrum analysis is that the width of the characteristic bands of a gas is proportionate to the number of molecules that intercept the light. Now, in last Sunday's experiment the most important rays of the oxygen group were precisely similar to those of the solar spectrum. The conclusion M. Jansen draws is that there is no oxygen in the sun.

Brooks' Underground Conductors. — Some particulars are forwarded to us, by Mr. David Brooks, of the comparative expense of the Brooks system of underground electrical conductors as compared with other systems. In the Brooks system the insulation is poured in at the time of laying, in the form of a thick resin mixture. For telephones on the ordinary system, with creosoted hemlock conduit and lead-encased cable for 100 wires, the cost is worked out at about £7 per conductor per mile ; and with iron pipe 3in. diameter, instead of wood, £9. With the Brooks system, the 3in. iron pipes will take 225 conductors, and the cost per conductor per mile is given at £4. 5s. For underground circuits for arc lighting the figures given are equally favourable. The cable of the Pennsylvania Railroad was laid two years ago on this system with 53 conductors, and there has never been a single interruption. Conductors for practical use were laid on the London and South-Western Railway nine years ago, and are certified by Mr. Preece as working without any trouble. Paraffin oil was used at first in this system, but the thick mixture of resin oil has now been substituted, and any slightly defective point will show no leak at all. The laying of the Brooks system is so simple and easily performed that it is the intention of the company to grant licenses to those who wish to use it, and let those parties do the work. Instructions and terms can be furnished on application to the Brooks Underground Telegraph Construction Company, Limited, 307, Walnut-street, Philadelphia.

The Birmingham Electrical Exhibition.—Preparations for the Electrical and Industrial Exhibition at Bingley Hall are being pushed forward with most satisfactory rapidity, and already nearly the whole of the space already available for exhibitors has been let. In the electrical department most of the best-known firms of electrical engineers and manufacturers of electric appliances will be represented, among them the Edison-Swan Company ; Anglo-American Corporation ; Messrs. Woodhouse and Rawson, Limited ; Elwell-Parker, Limited ; Laing, Wharton, and Down ; the Gulcher Electric Light Company, Limited ; the Planet Electrical Engineering ; the Julien Company ; Messrs. Fowler, Lancaster, and Co.; Shippey Bros.; Ernest Scott and Co.; Mr. Julius Sax; and the Acme Electric Works. The exhibitors in the steam-engine section will include such well-known firms as Messrs. Robey and Co., Ruston, Proctor, and Co., Galloways, and Greenwood and Batley. The general exhibits, of which there are several hundreds, will include some interesting manufacturing processes, such as ribbon-weaving, metal-plating, pen-making, breadbaking, bootmaking, etc. Messrs. Halmshaw, of Small Heath, Birmingham, are building a large three-manual organ for the exhibition, and the executive committee have engaged Mr. Gilmer's excellent military band to give two performances each day during the time the exhibition is open. The North-Western, Great Western, and Midland Railway Companies have promised to run cheap trains to Birmingham at frequent intervals, to give country people a chance of seeing the exhibition.

Uruguay.—A pamphlet has reached us from the Consulate of the Republic of Uruguay, 27, Throgmorton-street, E.C., which it would be well for manufacturers and shippers generally to ponder well. This republic is at the present moment in a state of intense commercial activity, and the whole country has been likened to a vast workshop. Buildings are springing up in all the cities, Monte Video and Rosario being the largest. Important undertakings of all kinds are in progress ; stores, stations, manufacturies, etc., in profusion are laid out and being erected. The demand for electric light is shown in the fact that at the Arroyo Seco, in Monte Video, a large electric light station is being constructed. The work is already far advanced, and in a short time will supply the public lighting of the whole city. Private buildings will also need the light, and the opening is apparently large for all kinds of electrical apparatus for business uses and the saving of labour. Three new tramways are to be opened this year, but whether electricity is to be employed at present does not appear. Telegraphs are laid, to the extent of 3,695 kilometres, by means of which all parts of the republic are in direct communication with each other. Telephones are particularly well patronised ; Monte Video with a population of 140,000 has 2,226 subscribers, and Rosario (51,000) has 1,546, being respectively 159 and 304 subscribers per 10,000 inhabitants. When it appears that the same proportion for Berlin is only 48, and Paris 21, it seems that Uruguay is wonderfully well developed in telephonic ways. It may well be anticipated that an equal and immediate development will take place in other branches of electrical engineering.

Electric Power from the Rhine.—An enterprise of considerable magnitude is under practical consideration, for the purpose of utilising the water power of the Rhine at Rheinfelden, for the distribution of power for commercial purposes throughout the adjacent district. Three large Swiss firms have combined to carry out the preliminary negotiations—namely, Zschokke and Co., of Aarau; Escher, Wyss, and Co., of Zurich; and the Oerlikon Company, of the same town. The village of Rheinfelden is about ten miles from Basle, and the Rhine, which here forms the boundary between Switzerland and Baden, would furnish, after the erection of the necessary plant, a power of some 15,000 h.p. This force would be distributed among the various industrial centres, which are numerous in this vicinity, with a radius of about 15 miles. For this purpose it is proposed to erect 20 turbines, each of 750 h p., coupled direct to Brown dynamos of 500,000 watts, producing 250 amperes each at 2,000 volts. Several of these would be connected in series, giving a total pressure of 4,000 to 8,000 volts for the distributing mains, reduced to the necessary potential for use at various secondary centres. The preliminary work being now finished, the proposers of this scheme are asking for a concession from the Grand Duchy of Baden for the purpose of erecting their station at Rheinfelden. The financial side of the scheme is regarded as satisfactorily settled, and the execution of the project will only depend upon the attitude of the authorities. It is hoped that a scheme of these dimensions, meaning, as it does, a very large step in advance in the application of electricity to the distribution of power for industrial purposes, will meet with the encouragement it deserves, and that the Govern-

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ment will grant the concession to these enterprising engineers.

Tenders for Electric Lighting.—The following tenders were sent in on the 8th inst. for the electric lighting of the Meirelbeke Station (Belgium) and its dependencies, and of certain portions of the central works at Gendbrugge: Legros Fils (Namur), 82,124f., 45 h.p. dynamos, 180 amperes, and 70 to 100 volts, with 775 revolutions; lamps and dynamos Zurich Telephone Company's system; guaranteed light 55 and 65 carcels per h.p. week.—Société Industrielle d'Electricité (St. Gilles), 124,474f., 40 h.p. dynamos, 180 and 15 amperes, and 65 to 400 volts, with 1,000 and 1,500 revolutions; Lahmeyer machines; Piette and Krizik, or Matisse and Bouverolle lamps; 102 and 76 carcels.—Société du Phénix (Ghent), 54,999 or 89,999f., 30 h.p., 66 and 91 amperes, and 220 and 65 volts, with 1,200 revolutions; Edison's machines; Halfat or Piette and Krizik lamps; 80 and 74 carcels.—Thomson-Houston International Electric Company (Ixelles), 51,819.60 or 40,837f., 24 or 18 h.p., 7 or 88 amperes and 825 or 60 volts, with 950 or 1,500 revolutions; machines and lamps, Thomson-Houston, 2,000 and 1,400 c.p., or 100 and 50 carcels.—Société Electrique (Laeken), 66,729f. (1), and 59,790f. (2), 45 h.p., 40 h.p., 600 and 1,200 revolutions, producing 80 and 105 amperes, and 250 and 60 volts, or 1,000 revolutions, producing 15 amperes—500 volts; machine, Victoria Compound and Brush and Victoria; lamps, Brush and Weschleer for both projects, 55 and 50 carcels (1), and 60 and 50 carcels (2).—Soc. Anon. d'Electricité et Hydraulique (Charleroi), 55,283.30f.; project (1) and 88,673.30 (2), 15 and 22 h.p., 500 and 625 revolutions, 140 amperes and 65 volts; and 900 revolutions, with 60 amperes and 225 volts.; Dulait machines and lamps, 55 and 58 carcels.—L. Bouckaert and Cie. (Schaerbeek), 8 proposals, 83,209.75f. to 49,700f.; Schuckert dynamos and Piette and Krizik lamps, 63 to 79 carcels.

A Universal Telegraphic Language.—The extreme cost of sending international messages by cable has prevented persons in general from using this facility for communication, except in the case of urgent necessity where cost is no object, and has to a large extent reserved their use to millionaries or large business houses. M. Léon Roquet has recently submitted to the French Minister of Telegraphs a project for a universal telegraphic language, which would afford a large benefit to the public for the cheaper transmission of cable messages. In the ordinary telegraphic dispatches there are a large number of phrases, conversational, financial or official, which occur time and time again. M. Roquet proposes that these constantly recurring phrases should be tabulated under certain conventional combinations of letters and figures. These ordinary words and phrases being similar in all languages, the same letter and figure would also serve for the same idea or thought by persons of various nationality, and thus form a real universal language, not spoken, but written, a "telegraphic language." He proposes to search the files of the last few years, noting the usual forms employed. These he would tabulate in the pages of a book, in columns, which should be headed with the letters of the alphabet, the phrases on each page having the numbers from 1 to 50. The book might contain, if necessary, a couple of thousand pages arranged for use in various departments, and in telegraphing, the message would read som thing like this "fk 2, d 3," etc. An ordinary message would contain only the number of letters or signs of a single word, or perhaps two, the message being written out in full at the receiving end. The cost of a cablegram, varying in cost at the present rates of from 6d. to 20s. per word, is now almost unthought of luxury for ordinary purposes, would be within the scope of private means, and at the same time greatly reduce the cost of official or financial transactions.

Increasing the Output of Transformers.—At Pittsburgh, it is announced that the experiments have been made, before some prominent gentlemen of that city, by Mr. E. G. Acheson, by which the output of transformers can be increased one hundred per cent. by the application in some manner of "heat, pure and simple." Mr. Acheson has been at work for several years in the problem of the direct conversion of heat, and regards one part of it as definitely solved. The invention is stated to cause the heat to impress converted energy upon an alternating circuit, in which electricity is already flowing, by the simple application of flame. The following is given as the account of an eye-witness: "An alternating current flowing through the circuit was measured and its total energy determined by careful calorimetric time-tests, which were checked by a simple form of Cardew voltmeter. The heat was then brought into play without any alteration of condition, so that the only possible variable in the combination would be the current due to increase of E.M.F. This took place at once at every repetition of the test, and the checking readings all corroborated each other accurately. The total energy thus measured was in every instance found to be upwards of one hundred per cent. greater than when the heat was absent." The writer, who, by-the-bye, does not give his name, says the process can be made cumulative, and increase can be obtained far beyond doubling the capacity. He points out the vast possibilities of the invention, in that a 500 h.p. plant could be reinforced to give 10,000 lights, and that without the enormous waste of 966 heat units per pound of water. Water power could be used to generate electricity, and coal then used to reinforce the output and double the power, by using an Acheson thermo-dynamic generator. The idea is certainly novel, and sounds rather like a Yankee joke. Several of their "jokes" have, however, before now turned out to be facts, but whether this one will have any real practical outcome we cannot, of course, say, without a good many further particulars.

Passenger Telpher Lines.—We understand that the United Electrical Engineering Company, Limited, have just closed a contract with the Mines and General Telpher Company, Limited, for the equipment of a telpher line to convey visitors from the Wood Green Station up the hill to the Alexandra Palace. The Palace seems to have entered upon a prosperous era, and it is confidently anticipated that the coming season will be a specially successful one. The Wood Green entrance is that by which a very large proportion of the visitors enter the grounds, and the line is for the purpose of conveying them from thence to the Palace and back. The simplicity and economy of electrical traction is likely to cause very great extensions in the equipment of light railways and tramway lines between towns and outlying suburbs and villages which are not yet provided with carrying accommodation, and the great practical development of telpherage, initiated by the Palace line, will doubtless command for the system a very great deal of attention. Even in the United Kingdom, where transport requirements may be said to be much better provided for than in other countries, a considerable amount remains to be done. A glance at the maps of either of the three kingdoms will show that large tracts of

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productive country are unprovided for, so that producers and the travelling public are placed at a considerable disadvantage in competing with those who are more fortunately situated. As has been pointed out by Mr. A. R. Bennett in respect to Scotland, it would certainly not pay to open up most of these districts by means of the ordinary steam railway, even if single tracks and light engines were adopted; but they might profitably be exploited by means of telpher lines or electric tramways laid either on the public roads or close beside them. In the case of the colonies and abroad, of course, the field is enormous, and it would seem that the telpher system may be a powerful factor in leading to the development of countries which either do not possess capital enough to build railways or even to make common roads, or have not sufficient traffic to justify a large expenditure.

London Central Subway.—This Bill came before a Select Committee of the House of Commons on May 9. It proposes the construction of an electrical subway railway between Holborn circus and Piccadilly, with stations at St. James's-street (Piccadilly), Piccadilly-circus, Cambridge-circus, the British Museum, Chancery-lane, and Holborn-circus. The London County Council, the City Commissioners of Sewers, the Strand District and the St. Giles's District Boards of Works, and owners and occupiers opposed the Bill; the *locus standi* of the Metropolitan and the Metropolitan District Railway Companies having been disallowed. Mr. Littler, Q.C., said that the resonance feared from the large quantity of metal used in the construction of the subway would be removed by the use of a material known as fer-flax, composed of iron and vegetable fibre shreds, which would be compressed and packed as panelling between the metal pillars of the subway. At the majority of the stations the public would only have to descend 12ft., or about 20 steps. Galleries would be provided for pipes and wires, which would remove the danger of overhead wires, and also the inconvenience of taking up streets to repair pipes. The carriages would be long cars on the American or tramcar system, each holding about 50 passengers, and would form almost a piston in the tunnel, each car being provided with safety wheels, on to which it would simply drop if an axle broke. A system of deflecting plates would keep a derailed train going along until stopped by the brakes, which would be magneto-electric—the quickest and most powerful known. The trains would run every two minutes, and at a greater speed than on the underground railways. The fares would be from end to end, 2d. first-class, and 1d. third. The inventor would be paid no cash for his patent, but there were 500 founders' shares of £1 each, which would receive one-half of the surplus profits after 5 per cent. had been paid to the ordinary shareholders on the capital of £750,000. Contractors were prepared to construct the subway for £350,000. Colonel Hazard, one of the promoters, was examined, and the committee adjourned. The Bill was further considered before the House of Commons Select Committee on Monday last. Evidence for the promoters was continued, Mr. Harrison Hayter, C.E., in the course of his examination, stating that the width of each train would be 8ft. 2in., the cars being of a size to give 6in. clearance on each side and above, and, acting thus as a piston, would insure ventilation without the blowholes to which objection had been raised in the underground railways. At the terminal stations he thought that the best plan would be for the two lines to converge into one, there being no locomotive to change, the passengers alighting on one side and the fresh ones entering on the other. He was of opinion that the subway could be constructed well within the estimates. Mr. Chatterton, a surveyor, was examined as to the practicability of dealing with the various underground gas and sewer pipes. The committee again adjourned.

The Thomson Meter.—Prof. Elihu Thomson has introduced an interesting modification into the present form of his oscillating electric meter, described by us in our issue of March 22, 1889. In the new form, the liquid is not transformed bodily from one bulb to the other bulb, but passes over in the form of vapour, which condenses, and thus finally overbalances the weight of the bulb which, for the time being, is being heated by the current. In the first form, the effect produced is an effect which is as the square of the current in the coil, for the reason that the heating effect is as the square of the current, and is proportional to the time of flow. The effect which one wishes to obtain in the case of a meter is, however, one proportional not to the square of the current, but directly to the current itself which is to be measured, and the object of Prof. Thomson's modification of his meter is to correct this effect, and to produce a registry in direct proportion to the current flowing on a lamp or power circuit. He does this by passing currents through the meter in direct proportion to the square roots of the currents in the circuit of the lamps, so that no matter how many lamps be in use, a correct record is shown. In the case of alternating currents a fair approximation is obtained by supplying the meter from the secondary of a small transformer, whose primary connects with the circuit carrying the current, the same as, or proportionate to, the current to be measured; and by arranging the coils of the transformer so that their inductive relation changes by reason of their mutual reaction. In one arrangement of this kind a double fixed coil is placed in a circuit with the lamps; mounted on a vertically pivoted shaft is a second coil, delicately poised, whose terminals are carried through to the heating coils. The second coil is, however, capable of rotation on its vertical axis, and, to avoid friction, its terminals dip into vertical cups filled with mercury, from which connection is made. A delicate spring, adjustable as to its fixed extremity, both in position and elasticity, is attached to an arm extending from the coil or its supporting axis. The spring, which is wound conically, and is of very light wire, is adjusted to pull in such direction, and its elastic force is made such, that alternating currents on the first coil will, when the second coil is circuited through the heating coil or resistance, cause deflection from the second coil to a position at which its plane approaches a right angle with that of the fixed coils. At the same time, the current induced in the movable coil by those in the fixed coils is as the square roots of the currents in the fixed coils. By suitable restraining influences governing the motion of the movable coil under the deflective actions exerted, a fair approximation is obtained to the conditions required. The idea is, in fact, to so adjust the parts in their relations of size and effect that the current induced in the movable coil by currents on the fixed coils shall always be in proportion to the square roots of the currents of the latter. Prof. Thomson has also applied the method to the direct registration of continuous currents, but this application does not seem to have proved so satisfactory as that we have just described for alternating currents.

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SANDWELL'S ACCUMULATOR TRAMCAR AND TENDER.

Experiments have been going on for some little time in a quiet way at Holloway, with an arrangement for running electric cars with the accumulators on a separate trolley or tender, the tender being hooked on in front or behind the car itself, and the motor and gearing only being carried on the car. We have already (on p. 298, vol. ii., Oct. 12, 1888) alluded to this form of electric car, which has been designed and carried out by Mr. W. D. Sandwell, of Victor Engineering Works, Victor-road, Holloway, London, N., near Finsbury Park Station, and we have expressed an opinion that this method of traction may possibly prove to be one of those by which accumulator cars will first be introduced practically on our English tramway lines. It is maintained by the maker that such a system is one which enables electric traction to be introduced upon the ordinary tramways without alteration of the lines, and with the least possible alterations of the present cars, while enabling the storage cells to be manipulated with ease, and without damage by lifting in and out; and at the same time saving the necessity for extra outlay in having, as usually proposed, either very large batteries of accumulators, or else two sets of motors, gearing and fittings, etc., as must be the case with a separate electric engine or locomotive to draw the cars. It is evident that one of three things must be done with the ordinary accumulator cars, or with electric engines: either the cars must be greatly strengthened and altered to carry sufficient cells; or an electric engine must be made large enough to provide energy for the whole day's trips; or else two engines are needed, each with complete motor, gearing, and all fittings. It is to obviate these necessities that the Sandwell car and tender has been introduced, and, at the same time, some special methods of working the cars have been introduced, which we shall place before our readers in this article.

The chief points about Mr. Sandwell's system are, first, the use of the separate trolley or tender, for which he claims an exclusive patent; and, second, the arrangement of two armatures mounted upon one spindle, the field-magnets of which can be shifted mechanically from one armature to the other—either for alteration of power, or, as more especially intended, for a safeguard in ordinary running—the second armature being able to be used after heavy running up hill if the first one has become at all heated, and also as a stand-by in case of a breakdown.

We are not here concerned with the discussion of the advisability of the use of double armatures—a matter that is open to discussion from various points of view—but with the description of this system as now practically proposed. It may be fittingly argued that electrical engineers should be able to make their armatures sufficiently well designed not to heat or to break down at all; but if at present it remains the fact that the armature is the weakest part of the usual systems of electric traction, it may be advisable for electric tramway engineers, if they are so disposed, to take means to obviate this weakness by the provision of double armatures. If this is the case, the device adopted by Mr. Sandwell admits of the ready substitution of one armature for another, by the simple movement of a lever handle on the car platform.

THE TROLLEY AND CAR.

The appearance of the special feature of the Sandwell system is shown in the illustration of the trolley as attached to the car, Fig. 1. A low car on wheels of the same gauge as the tramcar, and suitably painted and finished to correspond, is fitted with shelves for the storage cells, which are permanently connected up on this trolley, and after once fitting do not afterwards require removing. The lid is removable to allow of inspection, and the terminals of the battery are connected to flexible connections which are fixed at a suitable distance apart to a handle, which is constructed to slip into a double spring-catch connection on the car itself. The battery consists of 68 cells of the latest E.P.S. traction type, the available E.M.F. at work being taken as 130 volts on the car. The capacity of the battery is 140 ampere-hours.

The advantages claimed for this method of carrying the cells are that the cells, being permanently fitted and on separate trolleys, are so easily handled that the life should be considerably lengthened through the absence of the necessity for lifting about separately: the saving of labour

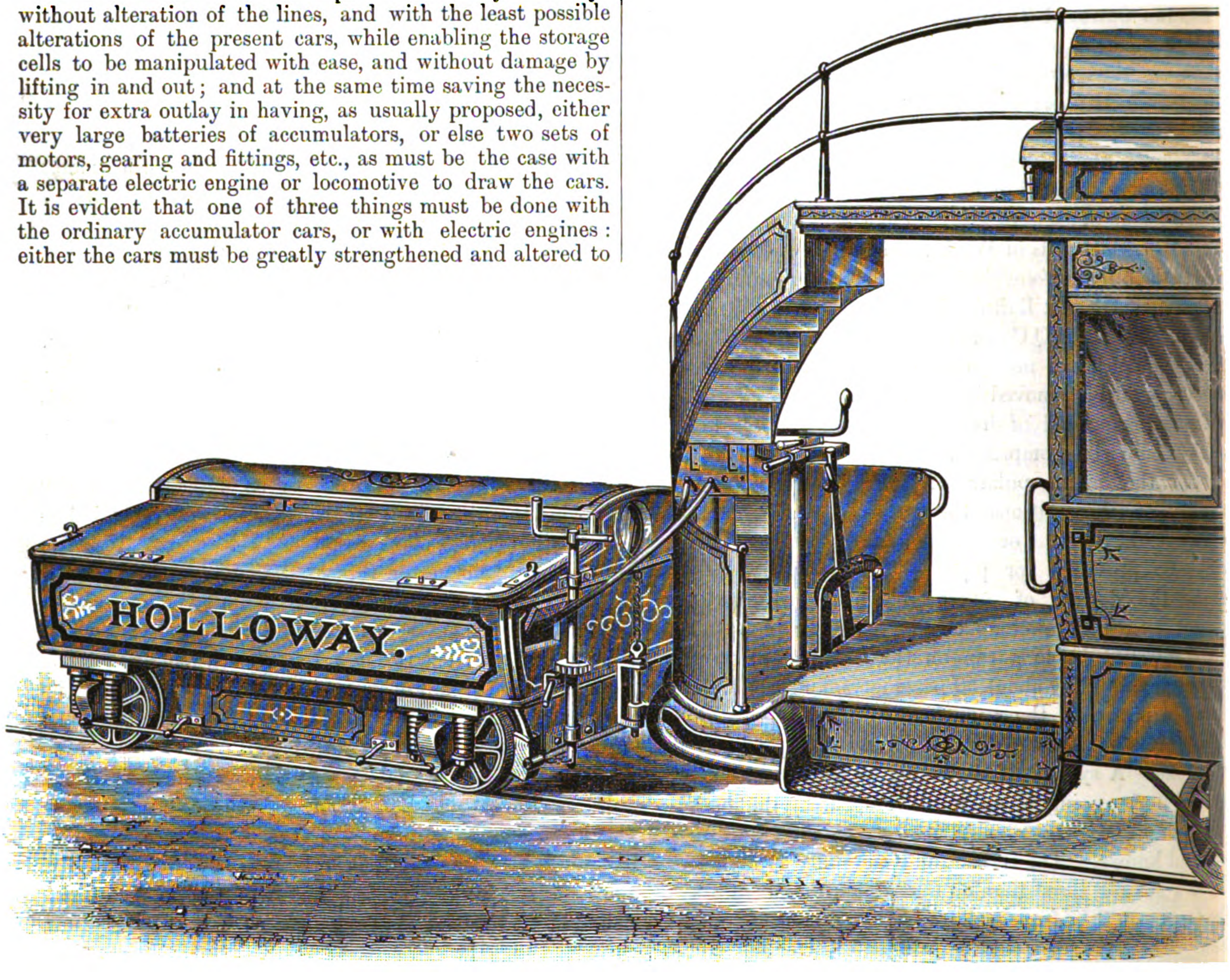

FIG. 1.—Sandwell's Accumulator Trolley and Car.

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is also a further advantage; while the danger or disagreeableness from acid being in the same car as passengers is entirely obviated, and no disadvantage from the occasional slopping of solution will therefore be noticed. The trolleys can be easily unhitched and run into the charging-shed; a small electric locomotive could, if found necessary, be employed for the shifting of the trolleys on a large system.

The Motor and Gearing.

The car used by Mr. Sandwell is one of the ordinary Moorgate-street trams, which has been lent by the North Metropolitan Tramway Company, the directors of which have considerably interested themselves in the working of their cars by accumulators on this system. The arrangement of motor and gearing is clearly seen in the accompanying perspective view, Fig. 2, which shows the car frame separately. Toothed gearing is used with double speeds, the driving power being communicated by belts. Two toothed wheels of different sizes are fitted to the axle of the car wheels. The motor drives by a belt upon two pulleys fitted to double shafting, the shaft of one pulley being solid, the other hollow, fitting over the solid one in the usual manner of hollow shafting. The shifting of the belt from one pulley to the other effects the alteration of speed as desired. Full details are shown on the plan of the car, Fig. 3, which also indicates the electrical connections to the switchboard and resistances. These connections are the same at both ends of the car.

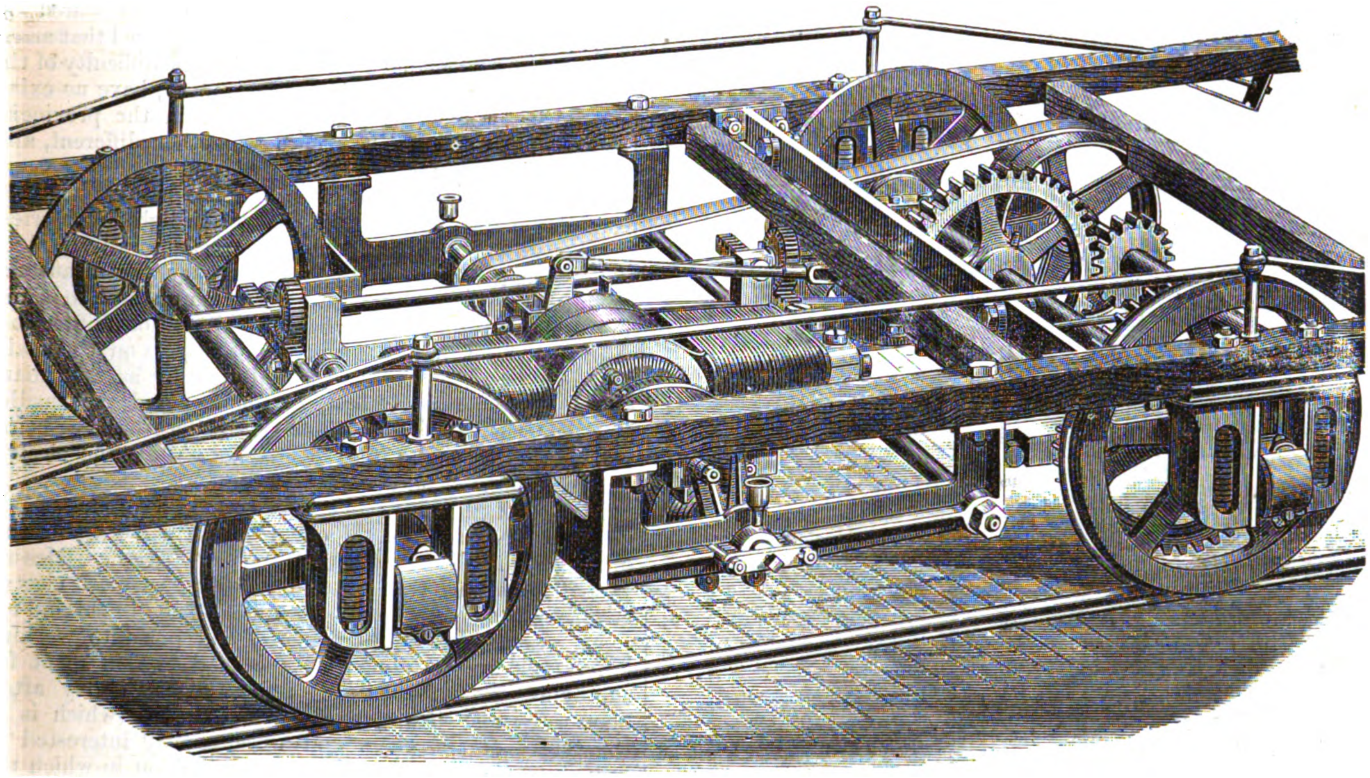

Fig. 2.—Frame of Sandwell's Electric Car—Perspective View.

The motor, which has field-magnets of the Siemens type, and a Gramme armature, has two similar armatures fitted upon one motor shaft. The armature is 12in. diameter by 9½in. long, wound with 580 turns of copper wire ·089in. diameter. The field-magnets are mounted upon a sliding carriage, which can be operated from the driver's platform by a handle, the working of which, by means of suitable levers and wheels shown, slides the field-magnets from one armature to the other, and at the same time shifts the corresponding brushes. A reversing lever also alters the brushes for the purpose of reversing the motion of the car. Mr. Sandwell uses vaseline for lubricating the gearing, and finds it remarkably satisfactory and cleanly, with no possibility of the splashing about of grease.

The usual current for the motor when in work is 35 to 45 amperes; it takes 20 amperes to start on dead level without load, 30 amperes with load. The car, as constructed, will mount with comfort at usual speed an incline of 1 in 30, and it can be made to mount 1 in 20 if necessary. For any very heavy incline such as occurs at Highgate Hill—a difficult combination of line to work profitably—it is proposed as the preferable method to have the storage station at the bottom, to work the whole of the line with the exception of the hill, by storage cells, and to have a conduit system for the steep part, disconnecting the trolleys at the bottom, and thus only necessitating the costly construction of a conduit line of a few hundred yards for the very steep part, at the same time not attempting to haul the weight of the accumulators up the incline.

The following tests of the motor have been taken with a Prony brake:

Test of Motor.

Speed.	Volts.	Amperes.	Weight on Lever.	H.P. on Brake.
620	150	45·5	38lb.	7·13
710	,,	45·3	35	7·53
720	,,	52·5	36	7·85
780	,,	46·0	34	8·03
790	,,	46·5	34	8·13
800	,,	46·5	34	8·24

Average h.p. = 7·8183. Electrical h.p. = 9·4604.
Efficiency = 85 per cent.

The weight of the motor and gearing is approximately 15cwt., the car itself 55cwt. A full load of passengers may be taken as about 52cwt. The weight of the battery and trolley is 40cwt. The car will run 24 miles with one trolley freshly charged, and it is proposed to change the trolley twice a day for each car.

Cost.

The items of cost can only be given approximately, but it may be taken that the cost of altering the car is about £25; the cost of the cells £110, two and a half sets being required for each car to allow for changing and repairs; the motor and gearing would be about £180 per car. The cost of running is calculated that it would allow of a contract being taken at 4½d. per car mile for lines with inclines not exceeding 1 in 30, of which the inclines will not exceed 20 per cent. of the whole length. Other easier or more difficult lines at proportionately less or more for the expense of running.

The experimental car and trolley constructed has made several trial trips from Holloway to Moorgate-street and back with satisfaction, and no difficulty is experienced in working the trolleys or the cars. The system is being worked out privately, Mr. Sandwell being backed up by several financial men of high standing to carry out the

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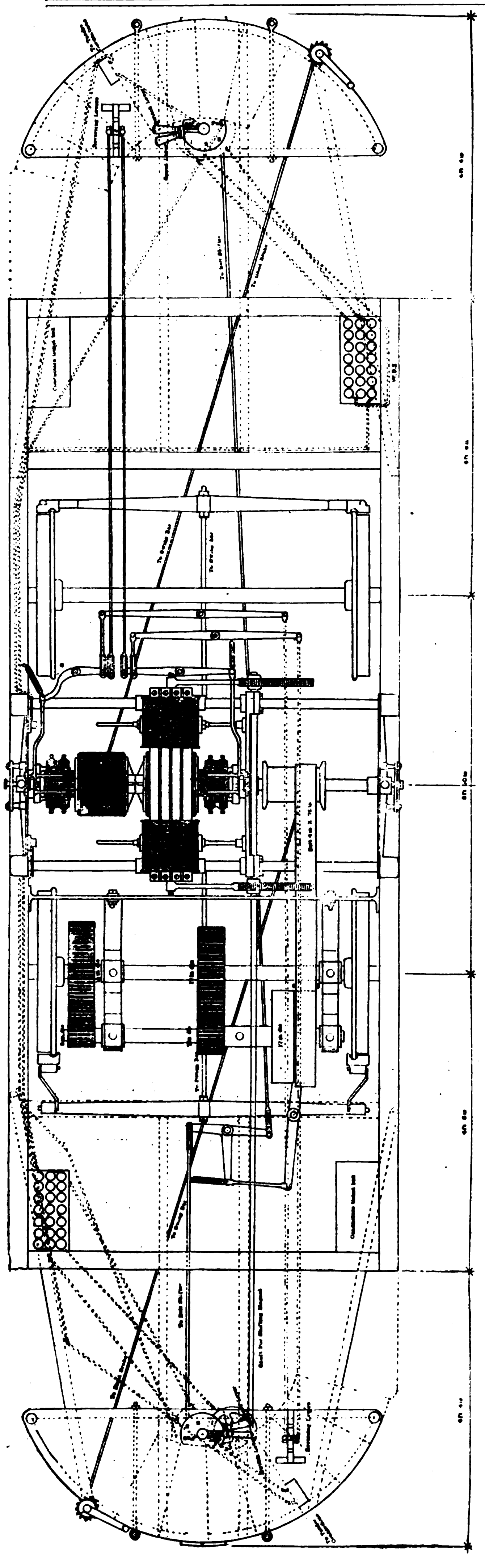

FIG. 3.—Plan of Sandwell's Electric Car, showing Details.

system, the details of which are now perfected, and it is expected to shortly undertake contracts for working existing tram lines on the combined car and accumulator trolley system.

CENTRAL STATION LIGHTING IN GLASGOW.

The electrical world has become so much exercised over the electric lighting of the metropolis, that the very promising field of enterprise in our large provincial towns is still comparatively virgin soil for electrical operations. Great amounts of capital have been placed at the disposal of electrical engineers for the exploiting of the electric light in London, and inventive genius has been busily—and profitably—employed in devising and carrying out a variety of schemes each claiming superiority in economy and in assurance of continuous and reliable working. In our larger provincial towns, however, we do not find amongst the local capitalists even a comparative appreciation of the electrical industries, and the employment of electric energy as a lighting agent for general use is to them an unknown thing. It may be that the troubles which have arisen, and which have militated so grievously against the extension of central stations in London, have scared off provincial capitalists; but it must be remembered that many of the factors which have contributed to the difficulty of the problem as it is presented in the metropolis, have no existence in the problem as it is presented in the provincial towns. There the conditions are altogether different, and the problem very much easier of solution.

In and about our large towns there are many admirable examples of the application of the electric light in factories, warehouses, and mansions, but there is urgently wanted, at these centres of population and industry, the means for placing the electric light within the reach of those to whom an "isolated plant" is impossible, by reason of its first cost or of their local circumstances. Shopkeepers on the main thoroughfares who use ornamental lighting as a brilliant and effective advertisement, warehouses and the smaller manufactories whose business necessitates their being situated near the business centres—to these the electric light should be at once available.

In view of the foregoing remarks, we have pleasure in directing the attention of our readers to a step in this direction which has now been taken in Glasgow. Messrs. Muir, Mavor, and Coulson, Limited, whose name as electric engineers has been well known in the West of Scotland for some years, have just completed and put into working order their first instalment of a central station plant for supplying electric light to the public. On Monday afternoon we visited their electric lighting station (which is in the centre of the city), and were greatly interested in examining the thorough workmanlike fashion in which the whole arrangements have been carried out. They have adopted the alternate-current transformer system and use the Ferranti dynamo and transformer. Although they have at present only one large machine, driven through rope belting by a 200 h.p. compound engine, they are not quite in the risky position of having all the eggs in one basket. A smaller dynamo driven by a 50 h.p. engine is available for day work and contingencies. They are thus able to accept customers to the extent of 3,000 to 4,000 8 c.p. lamps, but the preliminary arrangements are already completed for doubling or trebling that output. Indeed we understand that the existing plant will be doubled in the course of the next few months.

The price at which the electric energy is offered to the public is 8d. per 1,000 watt-hours, with a sliding scale of discounts according to the annual quantity consumed. Amongst others the city authorities have become customers to the extent of 1,100 16-c.p. lamps for the new municipal buildings in George-square.

We wish Messrs. Muir, Mavor, and Coulson every success in their new venture, and hope soon to hear that their plant is fully occupied. In conclusion, we again urge capitalists in our provincial towns to turn their attention to this outlet for capital. They will, we are assured, find in their own towns electricians who are willing, and as able

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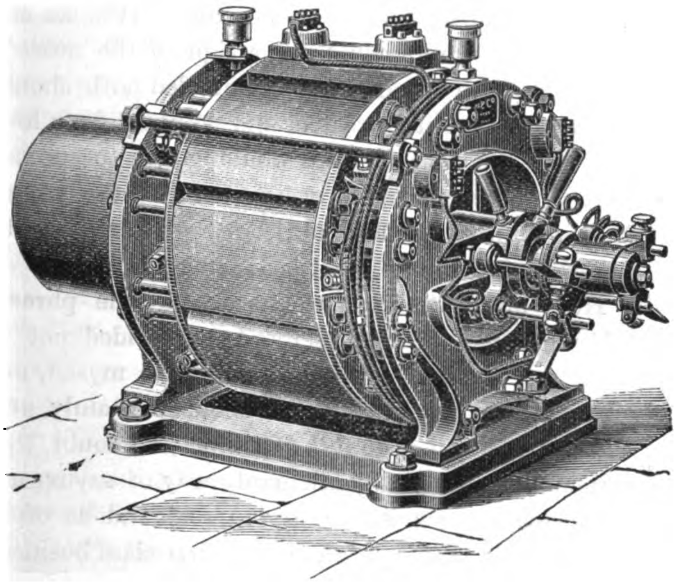
as they are willing, to employ that capital wisely and profitably in placing at the command of public consumers the great advantages of electric energy, as an agent for effective illumination and for the transmission of power. If local capitalists do their duty by this enterprise, the public will ere long be constrained to rise up and call them benefactors, and their banker's balance will be an increasingly pleasant consideration for their leisure hours.

THE GANZ ALTERNATE CURRENT MOTOR.

We are able this week to present to our readers a woodcut, reproduced from a photograph, of Ganz's alternate-current motor, reports of which of such favourable nature have been recently forwarded from Buda-Pesth. We have here, for the first time, according to the information received, an alternate-current motor, working up to 30 h.p., and giving a commercial efficiency of over 80 per cent. Such particulars as are received are given on the authority of Messrs. Zipernowski, Deri, and Blathy, the well-known electricians to the firm of Ganz and Co., and this firm, whose status as an engineering firm is beyond dispute, and whose practice on the installation of alternate-current plant is probably larger than any in Europe, now definitely announce that they consider the problem of the production of a really practical and efficient motor for use on alternate-current circuits completely and satisfactorily solved.



The Ganz Alternate-Current Motor.

Details of the construction and winding of this motor have yet to come, but in the memorandum which Messrs. Ganz have sent us accompanying the photograph, it is stated that the tests shown in the table we have already given were obtained with a model motor, the outcome of experiments extending over a period of four years. This model, although extremely satisfactory, does not itself show the highest efficiency to be attained, but has yielded results which give the clue to show what are the best methods of construction, and from calculations made they confidently anticipate the working motors will give an efficiency of over 90 per cent. in actual use. An important point, remarked upon by the inventors, is that whereas in the former attempts to construct alternate-current motors the *apparent* energy absorbed measured on the voltmeter and ammeter, and the *actual* energy absorbed measured on the wattmeter, were widely different, due to the employment of the alternating current. For instance, a motor taking 5,000 watts on a 100-volt circuit would show an apparent absorption measured in the ampere-meter of—not 50 amperes, as would be the case with continuous-current motors—but 100, or even 150 amperes. Motors on this model, therefore, even of a partially practicable efficiency, would necessitate leads and generators of greater size, such as would be impossible to employ on central station work solely for the distribution of power. In the motor shown, the apparent and the actual energy absorbed closely approximate, being in the experiments given 29,800 measured in *volt-amperes*, and 27,700 measured in *watts* respectively, the energy returned being 22,400 watts, thus showing a commercial efficiency of 80·9 per cent.

The objections to the types of alternate-current motors hitherto constructed may be thus stated: (1) their efficiency was far below that of continuous-current motors; (2) most types were unable to control the speed, so that the motor, even if it could be got to work at all, was useless practically on account of the speed varying most erratically as the load was altered; (3) that three or more conductors were needed for the supply of current; special types of dynamos were also required; or two dynamos of the ordinary type were necessitated to be coupled in a certain phase. How far Prof. Ferrari and Mr. Tesla, who have done most work at these problems, have overcome the difficulties has not yet transpired. The electricians of Ganz and Co. have pursued their work in other directions, and have produced a motor which they state can be thoroughly controlled in speed; can be worked on ordinary alternate-current circuits with ordinary lead and return wires; is very efficient, and with which they are perfectly satisfied.

Beyond the fact that the extension of alternate-current systems itself renders desirable the production of an efficient alternate current motor, Messrs. Zipernowski, Deri, and Blathy point out that this class of motor has distinct advantages over the ordinary class of continuous-current machines.

First, that it is easy and certain of regulation for constant speed at all variations of load within its working limit.

Secondly, as the high-tension current has not to go through any commutator, as in continuous-current motors, a higher E.M.F. can be safely used for these motors, with corresponding economy of transmission, as the conductors can be soldered directly to the terminals.

Thirdly: This fact, and the fact that the armature is fixed, allowing the employment of a higher potential, allows the network of mains for motive power to extend over a far greater area, and produce a correspondingly better service of power distribution.

Fourthly, for direct transmission of power, from waterfalls or other sources, it will allow for the employment of current at a potential impossible to work with continuous-current motors, and thus extend to far greater limits the economical employment of power from sources at a distance, which now run to waste.

Fifthly, that with continuous-current motors there is a limit below which it is impossible to construct really efficient motors for small powers, a fact that much militates against their extended use for household or business purposes, as distinct from manufacturing purposes, in central installations. On the other hand, with an alternating system it is possible to transform any current economically and without loss, rendering the smaller sizes of alternate-current motors far more economical than is at all possible with continuous-current motors, rendering their introduction into private houses for all purposes a practical possibility.

And lastly, with alternate-current motors there is no need of resistances to be inserted in the circuit at starting, the self-induction of the motor taking the place of resistance, and this fact again greatly simplifies the installation of motors. The construction of a good practical alternate-current motor is in reality the true solution of that most most important problem, the economical distribution of power from central stations.

But the most important item is that Messrs. Ganz are already busily at work installing their motors for practical work. At a paper mill near Innspruck a 50 h.p. Ganz alternate current motor will be used to drive the machiery, the motor being supplied from a 500 volt alternating machine, driven by a turbine at 1,000 metres distance. At Weiner-Neustadt two motors of 10 and 5 h.p. will supply a brewery with power from the distance of 2,000 metres. The power here is also obtained from a turbine driving a 2,000 volt alternator, which is also to be used for lighting the station by means of transformers, the first instance on record of the publc supply of light and power from an alternating-current station.

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THE

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NOTICE.

During the course of the past year we issued steel engraved portraits of MR. E. GRAVES, *the then President, and now the immediate Past-President of the Institution of Electrical Engineers, also of* W. H. WOLLASTON, M.D., F.R.S., *and* SIR HUMPHRY DAVY, F.R.S. *The portraits of* PROF. D. E. HUGHES, F.R.S., *and of* DR. J. HOPKINSON, F.R.S., *are engraved, and will be issued in due course. Other engravings are in preparation.*

FAITH.

It is not our intention to write a stirring story about a woman of this name, or to preach a sermon upon the scriptural definition of the term, though it may, perhaps, be in our minds to follow the example of Addison and Steele, and to drag in a moral somewhere. The time to get in a moral is opportune. There is nothing of overwhelming importance to comment upon just at present, though much might be said of the everlasting persistence of exhibitions. The text of our article flashed into our minds after the remark of a gentleman with whom we were conversing. "There goes," he said, pointing to a passer-by, "a man who ought to be proud of the unique position he has filled, as the boss of a company with a fairly large capital, who never managed to secure one bonâ fide commercial order during the time the company existed or while the money of the company lasted." How many would jump for joy to be put into such a position—the position, we mean, of manager—with plenty of funds, and the unlimited faith of shareholders and co-directors. It is, as our American brethren would say, a sign of the cussedness of human nature that unbounded faith should be placed where it is wasted, and withheld from him who has the capacity, and would go on to success were he not thwarted at every turn by those whose faith is limited, like the politicians' greatest good, to the greatest number—that being number one.

How often we hear of Jorkins in the phrase, "My partners or my directors have decided not to do this or do that, although, if left to myself, unfettered and untrammelled, I should certainly, and without hesitation, do it." Ofttimes, no doubt, this statement is only a gentlemanly way of saying no, but in many cases it is only too real, and as often detrimental to rapid progress. A first-class business man, be he manager of a small or a large company, must be tolerably conceited; the danger is in being excessively so. He must thoroughly believe in himself, and, by so doing, impress others with a belief in his ability. The failure of many companies has been due entirely to the distrust of every man for his fellows, and here again comes into play the blunderheadedness of shareholders who are apt to think that they, with a modicum of information, know better how the machine should be worked than the directors, who are familiar with every detail. Hence, usually, the shareholders are little consulted. They are told certain things have been done, certain things will be done, certain results obtained, and certain results expected, to give a vote of thanks, take their dividends, and pass out. They are asked for unlimited faith, and usually give it, when a concern is newly floated, or when it is fairly prosperous. Our remarks do not apply to other cases. If any real attempt is made to take shareholders into confidence, it leads to a row, and some-

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times to a change of directors, because it is impossible to enter fully into the business details which lead the directors to certain conclusions, and the half explanation which is given, as we say, leads to something different to what the directors desire. Success means full faith of shareholders in directors, full faith of directors in their managers.

Another direction in which huge demands are made upon our "faith" is as to any good arising from investigations into electric lighting matters. Many of the opinions expressed in the report of 1879, that is only ten years ago, might, for all the value they are, have been expressed in the time of Noah. We find now, as was found then, that the men who come forward, or who are paid to come forward, speak with considerable emphasis, but a year's or a couple of years' further experience is just as likely to prove them utterly wrong as right. Prof. Tyndall in the 1879 report, says "We are advancing towards perfection, whether we shall ever obtain it or not is another question." It seems that many people in the witness-box forget the possibility of further advance. Because this or that has not been done, or because they have failed to do it, is no proof that further advance will not show the work to be comparatively easy and simple. Various witnesses frequently in these investigations contradict each other point-blank, and hitherto the evidence has been ancient history before it was printed *in extenso.* The value of these investigations is to let rival organisations cut at one another's throats by causing the expenditure of huge sums of money unproductively. Pin your faith on the Board of Trade is the present cry. Well, we think the Board of Trade had better let local authorities settle their own affairs, whether those affairs concern electric lighting or the erection of a town pump. If the local people like to have overhead wires, what has the Board of Trade to do with it? if they insist upon underground, it is purely a local matter. If stirring competition is wanted, let the local authorities give carte blanche; if only a little competition, let them play off one company against a second. Surely each authority and each company is capable of looking after its own affairs and wants no wet nurse in the shape of the Board of Trade. This modern idea of making everything and everybody run in a certain groove by Act of Parliament is utterly subversive to the natural instinct of the Anglo-Saxon race, which tends more to self-reliance. But while the cry is "Home Rule" and decentralisation on the one hand, the action is towards centralisation and grandmotherly coddling on the other. There is still one other reference in this olla podrida to which we would call attention. Too much has been done and is being done in electrical matters that is of a non-paying character. John Bull, in the shape of a shopkeeper or a local board, is apt to say, "Show your own faith in your own wares, put up the light, and if it goes all right we may possibly come to terms and buy it." Now this exhibition of faith has led again and again to disaster. Anxious to show business, the private firm or the company has put down a temporary installation, with the result in a great number of cases that the temporary work has failed again and again, and so have the firms and companies. The public won't understand the difference between temporary and permanent; they don't want to, and we cannot blame them. The falling in with such whims is a sign of weakness on the part of the suppliers of the apparatus. If the temporary work is installed as if it were going to be permanent, all well and good, but it is not. The installers have not enough faith in their own goods or in the bonâ fides of the customer to do this, hence, what is done is done roughly and unsystematically, leading, as we say, to disaster.

CORRESPONDENCE.

PITKIN AND NIBLETT'S FIREDAMP METERS.

To the Editor of The Electrical Engineer.

Sir,—With reference to the firedamp meter which you have so kindly noticed in your leader last week, there can be no doubt that the whole of the questions which you so pertinently ask will have to be satisfactorily answered before we can expect these instruments to be generally adopted by miners.

When the meters were being exhibited at the Royal Society on the 8th inst., and again at the Royal Institution, 10th inst., great diversity of opinion was expressed as to the probable effect of time and repeated usage upon the active materials we employ.

I may say that all the points raised by you are receiving our most careful attention. A series of tests and practical trials are now proceeding, which, I trust, will bring out both the weak and strong points in this form of gas indicator. As time, and time alone, will be the only true test of the durability and active life of the spongy or finely-divided metals, it is somewhat premature to attempt an explanation of the apparent law or general effect of repeated and hard usage upon these substances. As far as our experience goes, no deterioration in the active part of the detectors under observation appears to have occurred. Should we find that a weakening or, as you term it, a tiring of the spongy metals occurs, this difficulty could be readily overcome by periodically renewing the active part. In the present form of these instruments, these renewals would be a very simple matter.

We do not anticipate the slightest danger which might arise due to a possible overheating of the spongy metals. The quantity of these metals employed is very small, and being placed directly on the bulb of the thermometers, the heat developed is rapidly communicated to the comparatively large mass of mercury in the thermometer bulb. Suppose a dangerous heating did occur, we still have the protection afforded by the wire gauze with which we surround the gas chamber. The gauze in this case would act exactly as it does in the Davy lamp. It is well known that the oil flame in the Davy lamp is rendered quite safe when in an explosive mixture, owing to that peculiar power of rapid radiation and diffusion of heat possessed by a fine metallic network. When enclosed within wire gauze, it becomes possible to safely utilise the light emitted by highly incandesced particles of carbon, which partly constitutes an oil flame. Mr. Pitkin proposes to substitute porous earthenware plates for the metal gauze. This arrangement would not interfere in any way with the free action of the gases upon the thermometer

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bulbs, and we should then avoid all possible danger arising from the overheating which you imagine might occur.

With reference to the advisability of employing an aural as well as a visual indication of the presence of explosive gas in mines, an electric bell attachment is now being fixed to an electric miners' lamp. These alarms will work quite automatically, and may be set to go off at any particular point.

To meet all requirements, instruments of various sensibilities will have to be made. Probably those having a range of from 5 to 15 per cent. would be found the most useful for ordinary coal-mining operations.

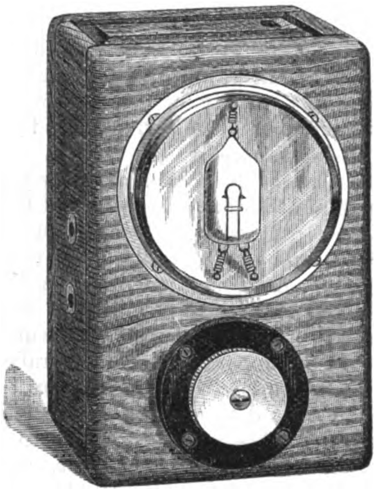
A form of instrument not yet shown, but which, owing to its great sensibility, may perhaps prove the most generally useful, is a two-bulbed differential air thermometer, having a short indicating mercury column. Under ordinary circumstances, and when the surrounding air is free from active gas, the mercury column will stand at a fixed zero at all temperatures. As soon, however, as the balance is destroyed by the unequal heating of the bulbs due to the presence of gas, an immediate displacement of the mercury will be produced. By suitable calibrations it is evident that this form of meter may be pointed off directly in terms of percentages without any correction for changes of initial temperatures.

I trust that I have not encroached too much on your valuable space.—Yours, etc., J. T. Niblett.

May 15, 1889.

THE PITKIN POCKET LAMP.

The Pitkin pocket lamp has been constructed with a view of getting a serviceable electric lamp in a very small and portable form. It has been designed, we believe, primarily for miners' use; but not essentially for this, as a small lamp is very generally useful for various purposes, if it can be carried about—for reading in trains, for astronomical telescopes, microscopes, and other scientific purposes, either combined with the battery or separate; and, with a ruby glass, would be very serviceable to photographers.



The Pitkin Pocket Electric Lamp.

The form of lamp illustrated is useful for any of these purposes where a combined and very portable little lamp is required. The total weight of the lamp is only 1lb. 13oz. complete, probably the smallest practical self-contained accumulator lamp yet made. The lamp is a 4-volt incandescent lamp, with bulb made of a flat shape to fit inside the glass reflector, and gives about 1 c.p. The battery is a two-cell secondary Pitkin battery, of five plates each, constructed with small projecting pins on the lead plate. It is contained in a vulcanite cell, which is fitted with polished walnut wood or oak. The charging terminals are two split tube ends, sunk just below the outer wood casing and connected to the terminals of the battery. The charging current is ½ ampere for eight hours. The lamp takes 0·35 ampere, and will burn with satisfactory light for six hours. It has a white or French-silver reflector at the back of the lamp; and the lamp itself is fitted by springs and a hook. The switch is operated by a milled screw-head, and inside has a resistance of 1 ohm, which allows the lamp to be turned on gradually and regulates the strength of the light when the battery is newly charged. The battery illustrated is the one exhibited at Mr. Preece's lecture, and lamps of the same form were exhibited at the Royal Society's conversazione. This kind of lamp has only just been made for sale, and it is a highly serviceable and efficient form of pocket electric lamp. The lamps are made by Mr. J. Pitkin, Red Lion-street, Clerkenwell.

FIREDAMP METER.

We herewith illustrate these ingenious instruments, which were fully described in our last issue. Fig. 1 shows a pattern that can be hung vertically upon any support. The two thermometers are seen, and the bulbs are covered with wire netting. Fig. 2 shows a pattern in the form of a watch, an exceedingly convenient form, as will instantly suggest itself to anyone. The meter will be constructed in other forms, such as the differential, wherein the mercury fills the bends of a U tube, the bulbs being filled with air, the expansion of which in one tube under the influence of the heat generated by the action of the gases and the platinum-black is greater than in the other, thus causing the mercury to stand at different heights. It will be seen from Mr. Niblett's letter that there is something to

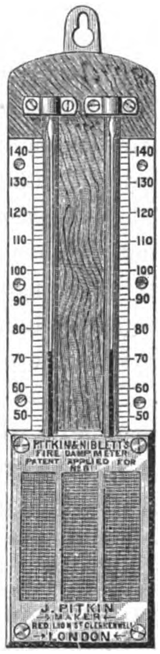


Fig. 1.

Fig. 2.

be said on the other side of the questions raised by us in our last issue. For the sake of the biggest and most important industry in the world, we trust that this instrument can be perfected.

ELEVEN YEARS ELECTRICAL PROGRESS IN CHELSEA.

The rapid progress of electric lighting is perhaps most clearly shown when we mark its course in one particular area; and as it is now about eleven years since the subject first received the attention of local authorities, it may be well to glance at the district of Chelsea to see what progress has been made there, especially as that district has always been to the fore in striving to place electric lighting on a sound basis as regards control by the local authority.

The desire for electric lighting in Chelsea was not an outcome of the electric lighting mania of 1882, but dates to some four years previous, when a letter was addressed to the Vestry calling its attention to a system of lighting

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gas lamps by electricity then in use in Pall-mall. This set the ball rolling. Attention was called to the unsatisfactory condition of street lighting in London generally, and the Chelsea surveyor was authorised to go to Paris to examine and report on the system of electric lighting in use there. Very little was known about electricity to the general public in London at that time. It was looked upon as a mysterious force, and the mystery was still further heightened by the erratic arc lamps which used to fizz and sparkle outside the Gaiety, and which were looked upon as one of the gazing-stocks of town.

The surveyor went to Paris, interviewed M. Jablochkoff and others, and reported that to light Sloane-street (1,100 yards long and 20 wide) by the same system as in use in the Avenue de l'Opera would necessitate two electric stations, each with a 16 h.p. engine, and the cost would be about £3,200, and the 32 electric candles required to light this area would cost 16s. per hour. The light would have been 31 times greater than gas. Naturally, such a system could not be recommended for ordinary street lighting when one engine would be required for every 16 lamps, so the matter was allowed to rest for a short time.

During the year 1878-9 an attempt was made to have a trial of electric lighting in and near Sloane-square, but as no definite or reasonable terms could be obtained the question still stood over.

During 1880-81 no negotiations were entered into, but the progress of electric lighting in the City was closely watched, and the result was quite as valuable to the parish as though a large expenditure had been incurred. In the year 1881-2 negotiations were opened with a firm who *thought* that they could light the neighbourhood of Sloane-square for £612 under the Brush system, but as gas cost less than £400 no further action was then taken. During the summer of 1881 the Electrical Exhibition at the Crystal Palace was visited and results noted. Towards autumn, however, the air began to be charged with electricity. An Electric Lighting Act was spoken of as certain next session. As a natural result many private Bills were talked of, and some few were considered by the Vestry, and the Board of Trade was communicated with. As neither the Electric Lighting Bill nor the private Bills provided for the submission of plans to the local authorities, the Board of Trade was appealed to, and a list of suggested amendments to the Electric Lighting Act were forwarded to Parliament. The Electric Lighting Act became law. Immediately, about half-a-dozen companies applied to light Chelsea. The Vestry, having decided not to apply for a license or provisional order themselves, agreed to support any company who would carry out the work upon condition of which the Board would approve. To discern the merits of the various companies was the next task. To do this the idea of giving each company an examination paper consisting of a series of questions was carried out. The answers obtained were instructive. Some would use 10 c.p. lamps, some 40, some 100. Some would use arcs of 2,000 c.p., and some 3,000 to 6,000 c.p. Some thought one central station would do, while others knew it would not, but one and all declined to give a reliable estimate.

The Brush Company then submitted a draft order. It was amended and reamended, and subsequently became the model for all orders before the Board of Trade. The company, however, did not proceed with it, and in July it was revoked.

In June, 1884, Colchester was said to be basking in the light of electricity, and thither the surveyor was despatched to investigate and report. This was found to be only a system of private lighting, and storage batteries were mostly used. In December, the draft of a new order was received, and after the authorities had been put to great trouble to amend it, it was abandoned when before the Board of Trade, the 21 years' purchase clause being the rock on which it foundered. In November, 1885, the Chelsea Electric Lighting Order, 1886, first made its appearance, and in September, 1886, was confirmed by Parliament.

After this there was a pause, and while the company who had obtained the order were doing nothing, a rival company commenced to put up overhead wires and to give light.

The science of electric lighting was now something to be relied upon, so in 1887 the Vestry did not hesitate to allow the second company to enter into an agreement on very much the same terms as the company who obtained Parliamentary sanction, and have repeated the same course during 1888 to another company.

There are, therefore, now three companies supplying electric light in Chelsea, and all three are under the control of the local authority. There is a feeling among the ratepayers that their interest will be looked after, and a feeling among the companies that they will be treated with perfect fairness.

In conclusion, electric lighting in Chelsea is now an accomplished fact. Two out of the three companies have central stations in the parish. Companies' scrambles and squabbles have been put down with a firm hand, and neither the public interests nor the interests of a genuine company which desires to do a fair business, will suffer in the long run. But it has taken years of hard work.

ON LIGHTNING, LIGHTNING CONDUCTORS, AND LIGHTNING PROTECTORS.*

BY DR. OLIVER LODGE, F.R.S., MEMBER.

(*Continued from page 381.*)

Instructive Extracts from Reports of Damage by Lightning.

40. Reading between the lines of existing reports on damage done, one can frequently find evidence of many of the phenomena to which I have now called attention. Of course, they are not recorded in any prominent manner, because they are to the observers ill-understood and puzzling facts: it is very difficult to note what has exactly happened in any given case unless some clue or expectation has been formed beforehand. The bad conductivity clue, which was the only one prominently available to the skilled recorders in the following cases, is a very partial one, and in many cases is quite insufficient to account for the facts without undue pressure being put upon it. Under such circumstances the record of the facts is, of course, far more valuable than the comments made upon that record; and in the following extracts the theoretical remarks should be eliminated or slurred over. One minor imperfection, common to many accounts, is that they are not sufficiently alive to the possibility of all manner of branching discharges; so that the discharge is said to leave a conductor and go to something else, when the truer statement would be that some *portion* of it branched off at such and such a point.

In the following quotations the references are usually to the pages of the volume of the Lightning Rod Conference, published by Spon in 1882:

41. Illustrating side flashes and surging circuits.

"*L.R.C.*, p. 39.—*J. Murgatroyd, St. Mary's, Crumpsall, near Manchester.*—A lightning-conductor from spire touched the eaves gutter, and a gaspipe touched the end of this gutter. The lightning passed from the conductor along the gutter to the gaspipe, melted it, and set the church on fire by igniting the gas."

"*L.R.C.*, p. 39.—*Wyatt Papworth.*—Tall spire struck. The church stands in an open position, with no large trees near. It was provided with an iron lightning-conductor ¾in. diam., fixed with iron holdfasts, and carried down inside the spire and tower into ground. The top of it was said to be attached to a bold copper finial on the spire about 150ft. from the ground, and 50ft. above ridge of roof. The lightning is supposed to have first struck the finial. It slightly deranged some beds of masonry in upper part of spire, then descended by iron rod to belfry, melted a gastube in the floor, and set fire to the belfry by igniting the gas."

From Abstract of Report on the Destruction by Lightning of a Gunpowder Store at Bruntcliffe, Yorkshire. By Major V. D. Majendie, R.A. (L.R.C., p. 77.) "The gunpowder exploded at 4.30 p.m. on August 6, 1878, during the greatest intensity of a violent thunderstorm. The building was brick, with brick arched roof, length 9ft., width 5ft., height 6ft. (internal dimensions). The store had a uniform thickness of three bricks, and was furnished at one end with an iron door, at the other end with a lightning-conductor. The conductor consisted of a copper wire rope, 10 gauge copper wire, the rope being $\frac{7}{16}$in. thick, having four points at the top (one large one in the centre, and three smaller ones round it); it extended to about 13ft. above the top of the building, and about the same length was carried into the ground and terminated in a drain. The conductor had been erected in 1876 by Mr. John Bisby, of Leeds, and was fixed to a

* Paper read before the Institution of Electrical Engineers.

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pole distant about 2in. from the end of the building opposite to that in which the iron door was fixed (it was not connected with the iron door in any way). No one was near the store when the powder exploded, and it seems probable that [the earth connection of the conductor was bad, that] the mass of iron in the door offered at least an equally good path—and that the gunpowder was ignited by a flash passing between the two imperfect conductors." To make this report more completely scientific, it would be well to omit the words I have put in square brackets.

Extract from a reply of Mr. Baldwin Latham, C.E.—"It is no uncommon thing for buildings provided with what are called lightning-conductors to be damaged by lightning, and the cause is due to the inadequacy of the conductor to carry the electric fluid, which will leave the conductor for a better or a larger conductor." (See also sec. 43.)

42. As illustrating that a good conductor affords no absolute security, the following document is worthy of reproduction in full, as given in *L.R.C.*, p. 115 :

"*Ueber Blitzableiter und Blitzschläge in Gebäude welch mit Blitzableitern versehen waren. Von G. Karsten. Keil.* 8vo., 1887. (*Abstracted by R. Van der Broek.*) In this pamphlet Dr. Karsten gives an account of two cases in which buildings that were provided with lightning-conductors were damaged by lightning. The author states that the statistics for the year 1873 show that in Schleswig-Holstein 26 per cent. of all the cases of fire were caused by lightning ; $\frac{1}{10}$ part of these cases occurred in the towns, and the remainder in the country. Do lightning-conductors guarantee absolute protection ? The author answers this question as follows : There is no absolute certainty in empirical matters. Each new case may direct our attention to circumstances that had been overlooked. If lightning-conductors cannot be said to ensure perfect safety, they certainly afford a very high degree of protection. The flash of lightning which struck the church at Garding on May 18, 1877, fractured the conductor in fifteen places, and pierced the wall of the steeple in two places. The inefficiency of the conductor resulted from the carelessness with which it was fixed ; the line was laid down the north side of the steeple and fastened with 25 wall eyes. These wall eyes were hammered too deep into the wall, thus damaging the line and forming a short and sharp bend in each case, besides also unduly straining the wire. The damage to the steeple was the consequence of a neglected secondary circuit. There are an excessively large number of tie-rods in the steeple ; the heads of these rods are not connected together, neither are they, except in one case, in close proximity to any of the larger masses of metal that are about the building. The conductor passed close to one of those heads. The south side of the steeple, where the opposite head is, becoming wet through the rain, a secondary circuit was formed, and a return shock followed ; the damage to the steeple was trifling. The rod was provided with a conical point, rather blunt, but surmounted by a short platinum point. The copper line-wire was of good material—not of a uniform thickness, but at the weakest places not weighing less than 240 grammes per lineal metre (8oz. per yard, or rather less than ¼in. diameter if solid). The earth-plate was sunk into a well 10 metres deep, and tested faultless after the discharge."

43. The following series of notes are better not separated, though they bear upon different points :

L.R.C., p. 93, *et seq.*—*From Abstract of Statistics of Buildings and Ships struck by Lightning. By F. Duprez, Member of the Academy.*

Illustrating occult dangers from secondary disturbances in the neighbourhood of conductors.—"The author cites three cases of buildings set on fire, though protected by lightning-rods. But the precise cause of the fire was not ascertained."

Illustrating multiple flashes.—"In each of two cases the lightning struck at once the three rods fixed to a building."

Illustrating that a poor earth is not necessarily fatal to the efficiency of the conductor, except as to the protection of the soil itself and of things buried in it.—"Out of fifteen cases of lightning-rods struck, in which the conductors were simply buried more or less in the soil, they carried off the strokes in eleven without the buildings being injured or any trace being left of it, except that the ground was upheaved where the latter was too dry."

Illustrating a matter important, if true : suggested by Prof. Fitzgerald theoretically at Bath : not yet verified by me.—"In two cases the stroke broke the conductor at points where its direction was abruptly changed."

Illustrating side-flash.—"In two other cases the lightning left the conductor struck, and fell upon buildings near, without causing damage to those on which the rods were fixed."

Illustrating brush discharge from conductor, and surging circuits its neighbourhood.—"Two electrical phenomena are to be noted as sometimes occurring when a lightning-rod is struck. First, when a conductor is formed of metallic plates, a peculiar noise is heard, like water pouring on a fire. Second (independently of the form of the conductor), electric sparks are emitted from bodies near. The author cites examples at Berne, 1815."

44. The following illustrate the carrying power of fairly thin wire, and the fact that thin wires may protect although themselves deflagrated. *From Mr. Preece's paper on "Lightning" to Society of Telegraph Engineers, November,* 1872 (*L.R.C.*, p. 101) : "There were only two cases in the past season where line wires (No. 8 iron 0·17in. diam.) were absolutely fused."

From letter by Admiral Sullivan (*L.R.C.*, p. 195): "You will like to know a case in which a copper wire acted as a perfect conductor, *though fused throughout its length.* It was at Monte Video, in the house of the English Consul. A flagstaff was struck, and conducted the lightning through a flat roof near the bell wire of a suite of rooms (the wire ran in sight near the cornice), through a hole in each dividing wall, and then down to the bell in the basement. The wire was melted into drops like shot, which burnt a row of small holes in the carpet of each room. A dark mark on the cornice above showed where the wire had been. At the bell there was a slight explosion and some little damage ; but I do not recollect whether anything acted partially as a conductor from that point, and so carried off that part of the charge. This, I think, shows that even an ordinary bell wire will act as a conductor for a rather strong stroke of lightning, as the large flagstaff was shattered."

45. As illustrating that experience has led to the perception of the value of large surface to a rod, I may quote the standard American work, Spang's "Practical Treatise on Lightning-Conductors." Philadelphia, 1887 (*L.R.C.*, p. 113) : "A conductor of large surface exercises a much greater protective action than the same quality of metal in the form of a wire or solid rod. Not because electricity in motion resides on the surface, but that the expansive action of a discharge may have a wider scope through the metal."

[The incoherence of the reason does not destroy the correctness of the stated fact.]

Messrs. D. Munson and Co., of Indianapolis, Indiana, have sent me specimens of their rods, which have flanges and sharp edges, and in various ways aim at large surface. Their rods are composed of copper and iron mixed, which is curious, and their mode of attainment of large surface is needlessly complex.

The following illustrates the contradictory views about manner of conduction by lightning-rods. *Letter from Admiral Sullivan* (*L.R.C.*, p. 199) : "I firmly believe in the surface theory of Harris. I had been with him often when he made experiments nearly fifty years since, and witnessed a strip of tinfoil of the thinnest kind, and about ¼in. wide, protect a model mast of about 6in. in diameter from electric shock, that without it split the mast to pieces, aided by a small hole through its centre filled with gunpowder. And I always thought that the surface-conducting theory of Harris was indisputable. But about 20 years since, having to approve a proposal of the Trinity House for a new conductor of a lighthouse, which, like previous ones, was an inch in diameter copper rod, called 'Faraday's Plan,' I thought I would go up to the Royal Institution and ask him why he did not use a copper tube instead, giving much greater conducting power with less copper. I did so, and he asserted positively that the conducting power depended entirely on the volume of copper in the section of the conductor, no matter whether it was in a bolt, plates, or tube ; and that if Harris said differently, 'he knows nothing whatever about it.' Of course, I approved the rod conductor ; but singularly enough, though I had not seen Harris for years, he came to town a few days after, and came to the Board of Trade to see me, and bring me piece of his large tube conductor, with a connection, that he was fitting to the Houses of Parliament. When I told him what Faraday's opinion was, he answered, 'Then he knows nothing about it.'"

46. I may call attention to some apparently sound doctrines in a paper by Capt. Bucknill, R.E., abstracted in *L.R.C.*, p. 242. That lightning can penetrate into collieries is proved by an account of a meeting of mining engineers (*L.R.C.*, p. 237). The same sort of thing is illustrated by the accident at Bootham Bar, York (*L.R.C.*, p. 219), when the lightning struck down into a cavity surrounded by high buildings with lead roofs, iron rain-water pipe, and an iron portcullis, to get at a street bracket 11ft. 6in. above the pavement, melting its pipe, and setting a house on fire by the large flame produced (*L.R.C.*, p. 219).

47. That the existence of gaspipes make houses more difficult to protect, and in fact causes dwelling-houses to require almost as much attention as powder magazines, can be illustrated by a good number of extracts. The following may serve (*L.R.C.*, p. 239) : "On July 13, 1880, during a thunderstorm, the large 400-light gasmeter of this mill, though locked up in a cellar, and with no light near it, exploded, and the gas, which is supplied through a 4in. main, was ignited. This was repaired, but on July 5, 1881, during another thunderstorm, precisely the same accident occurred."

From an interesting report, signed J. Gavey, on damage to a church at Cardiff (*L.R.C.*, p. 218), I make the following extract : "On examining more closely the surroundings of the lightning-conductor, I observed that the church gaspipe, an iron one, about 1¼in. in diameter, passed through the wall of the building about 6ft. from the conductor, and was carried in a direction corresponding with the hole caused by the explosion (see plan). I immediately concluded that this explosion was due to the current breaking across from the conductor to the gaspipe, and

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on opening up the hole, I found this to be the fact. The conductor crossed the gaspipe at nearly a right angle, being about a foot above it. The under portion of the conductor bore evident marks of fusion, and, more interesting still, the gaspipe was slightly coated with a very thin deposit of copper, so thin that it perished in my attempt to remove it; but still there was an undoubted coating at one spot."

Continuing the account of this kind of damage, the following interesting remarks by Prof. Kirchhoff have a bearing on the important practical question whether gaspipes should or should not be utilised for earth; but their main utility lies in the proof afforded of the unique kind of danger which gaspipes introduce.

(To be continued.)

SECONDARY BATTERIES.*

BY J. APPLETON.

In considering the theory of the secondary battery, we will first trace the action which takes place in a fully-charged cell during the discharge. We have the two plates immersed in dilute sulphuric acid (H_2SO_4), the active material on the anode, or positive plate, being peroxide of lead, and on the cathode, or negative plate, spongy or finely-divided lead. During the discharge the positive plate gives up its oxygen, and the negative plate its hydrogen, so that when the discharge is carried as far as practical work will allow, we have at the anode peroxide, a lower oxide, and sulphate of lead.

This lower oxide is rapidly acted on by the sulphuric acid, and if the cell is allowed to stand in a discharged condition it becomes sulphate of lead. At the negative plate we have sulphate of lead. The chemical formula is

$$PbO_2 + 2H_2SO_4 + Pb = [PbO + H_2SO_4] + PbSO_4 + H_2O.$$

The compounds bracketed react, and the final result is

$$2PbSO_4 + 2H_2O.$$

There are two kinds of sulphate of lead—viz., $PbSO_4$, and Pb_2SO_5. The former is not very difficult to reduce or oxidise, but the latter, Pb_2SO_5, is the basic sulphate which is formed when the cells are in a bad condition, or are allowed to stand when discharged. It is very difficult, if not impossible, to reduce or oxidise this sulphate, and in charging cells in which this white basic sulphate is present, it will be noticed that it generally falls to the bottom of the cell in a fine powder.

The acid density of the electrolyte falls during the discharge as the sulphate is formed, and the specific gravity usually drops from 1·210 to about 1·160, though, of course, this depends entirely on the quantity of electrolyte in the cell. When the plates are charged the opposite action takes place: the electrolyte is decomposed, oxygen is taken up by the positive plate, and hydrogen by the negative plate. This goes on till all the active material is peroxidised and reduced in the respective plates.

When the greater part of the active material has been thus restored to its original condition, the oxygen and hydrogen not being absorbed by the plates so readily, pass off in bubbles, and it will be noticed that at this point the E.M.F. required to charge the cell rises very rapidly. This is due to the hydrogen bubbles on the negative plate, which causes a false or spurious back E.M.F. This, of course, lowers the efficiency of the cell, but can be overcome if the charging current is reduced when gas is given off from the plates. The active material will only absorb the oxygen and hydrogen at a given rate, and as the plates become charged the amount of active material to be acted upon is reduced, consequently the gas is given off in bubbles; but if the charging current is also reduced the quantity of gas formed by the decomposition of the electrolyte is less, and it is all absorbed by the plates. This is practically the theory of the lead secondary battery. There are differences of opinion as to the exact chemical action, but this will be sufficient for our purpose to-night.

As long ago as 1835 the highly negative or oxidising property of peroxide of lead was discovered by Munck, and in 1838 Shonbien described in the *Philosophical Magazine* the high E.M.F. of plates covered with peroxide of lead.

In 1843 Wheatstone experimented with platinum plates covered with peroxide of lead, and C. W. Siemens in 1852 made a battery using carbon plates impregnated and coated with peroxide of lead. In all these cases, however, the inventors used their plates as primary batteries only, and did not seem to know of the properties which they contained of being regenerated by charging. It was not till 1859 and 1860 that the principle of storage batteries was made known, when Gaston Planté published the result of his researches, and made the first reversible lead battery. His first cell was made of ordinary sheet lead. He took two sheets and rolled them up into cylinders, separating them by felt or strips of guttapercha, and then charged and discharged them in dilute sulphuric acid, reversing the direction of the current at each charge. He seems fully to have understood the importance of this discovery, and his experiments are fully described in a book he published at that time.

It is rather doubtful whether Planté used a coating of oxide mechanically applied to the lead plate, but Faure was the first to patent and introduce the pasted type of plate, and his are the fundamental patents for the batteries of this type. He pasted his lead plates with a paste of red lead mixed with sulphuric acid, using felt or parchment to keep the coating on. This plate was improved by Swan, Sellon, Volckmar, and others. Swan's patent for the perforated plates or grids is of the most important.

There have been many other batteries made, but I shall only mention to-night those which hold the most prominent positions. Messrs. Gladstone and Tribe, and also Fitzgerald, have been working in the direction of solid peroxide positives, and I shall say more about this type later on. An ideal secondary battery in my opinion is one which fulfils the following conditions. It must be cheap and durable, and able to take care of itself under ordinary working conditions; must charge and discharge rapidly, and give the greater part of its capacity with little or no fall of its E.M.F.; must be of very low internal resistance, and the internal resistance must be constant during the discharge, as if it increases at the same time the E.M.F. falls, the terminal E.M.F. of the cell is greatly reduced.

In a good cell the open circuit E.M.F. and terminal E.M.F. should fall in direct proportion. The cell must not require over-charging to keep it in good condition, but should be cut off from the charging source directly gas is given off when charging at a fair rate. Must be able to stand idle for a long time without local action taking place, and finally must make use of a fair percentage of the active material in the plates. When this state of perfection is attained it will be very easy to charge and discharge cells, automatically cutting them off by the rise and fall in E.M.F., and so working much more efficiently than at present. The modern tyes of secondary batteries are chiefly of two classes—one in which the active material is formed by the continued electrolytic action, and the other in which the active is mechanically applied to a supporting frame or conductor.

We will first consider the former class—viz., the Planté type of cell. The only batteries of this type at present in the market are, I believe, the Crompton-Howell and Elieson. The latter is not now being manufactured, but has done some fairly good work. (There is a plate here which shows the construction.) The Crompton-Howell battery has been designed, and is used chiefly, for central station work, where a very high rate of discharge is required for a short time. The plates are made from porous lead blocks sawn up into plates of the desired thickness, and formed by charging and discharging till the proper capacity has been obtained. They are very porous, so that the action penetrates right into the centre of the plates, and a large surface is exposed to the electrolyte. I have a positive and negative plate here; and you can see how porous they are, and yet mechanically strong.

I would just say a word here about the various electrolytes which can be used in secondary batteries. Undoubtedly sulphuric acid and water is the best for continual work, but for quickness of forming there are others which allow the oxidising action to penetrate more deeply into the surface of the lead. Sulphate of magnesia and sulphate of soda are very good, and with the former especially I have obtained excellent results. A very soft and porous peroxide is obtained with this electrolyte, but if the action is carried too far it disintegrates. A very good plan is to form for a time in sulphate of magnesia, and then change the electrolyte to sulphuric acid, which hardens the peroxide. The cathode does not fare so well with this electrolyte, as a thick film or scale forms (probably a silicate), which is a bad conductor, and increases the resistance of the cell. The Crompton-Howell battery gives very good results with rapid discharges. For example: T 25 type, containing 125lb. of lead, the external dimensions being 14in. × 12in. × 12in., can discharge at 100 amperes for four hours, and this can even be increased up to 500 amperes, provided the capacity is not drawn on for more than 100 ampere hours. This is very useful in certain cases, especially in central stations on the accumulator system, as practically the whole of the demand can be met for a short time from the batteries if anything happens to the engines or dynamos. The rate of charge for this cell may vary from 50 to 75 amperes. Beyond this there is a decided loss in efficiency; but the plates do not seem to hurt if there is plenty of electrolyte in the cells. In these cells each plate is separated from its neighbour by a perforated corrugated ebonite sheet, and in the latest type the plates are arranged in sections, so that any section may be removed for repairs or cleaning without interfering with the working. The second class of battery—viz., the one in which the active material is mechanically applied—is represented by the E.P.S., Drake and Gorham, Tatham, and Reckenzaun cells. The E.P.S. cells are too well known to need much description, but I will just mention some of the recent improvements that have been made. In the latest type the plates are put farther

* Paper read before the City and Guilds of London Old Students' Association at the Technical College, Finsbury, on Wednesday, May 8.

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apart—viz., about ⅝in. This allows more room for the electrolyte, which is of very great importance.

It is very necessary that there should be sufficient electrolyte for the work which has to be done in the discharge. If there is not, only part of the active material in each little plug or pellet becomes useful, the centre part remaining, practically, idle and useless. This is not only wasteful but injurious to the plate, as the action occurs unequally in the plugs, and causes them to disintegrate. This occurs especially if a cell is discharged beyond its normal rate, as the edges of the plugs become softened, and there is nothing to keep them from falling out. By using more of the active material in each plug, not only is a greater capacity obtained, but also a higher rate of discharge.

In the 1888 type of cell the negative plates are joined by metallic conductors in three plates; this reduces and equalises the resistance of the plates, and causes the work to be distributed more evenly over the whole area. [31-L cell, traction cell, and unpasted grids shown.] The cells made for tramcar and launch work are capable of discharging at very high rates—viz., T 23 type, containing 23 plates and weighing 80lb. with box complete, discharges up to 50 amperes. This company have quite recently introduced a new form of grid which is very different from the old form, and is very interesting and ingenious. The two holes of the mould or chill in which the grids are cast have been moved corner-ways through a space just equal to half the size of a square, so that the corners of the squares in one half chill come exactly in the centre of the square on the other half of the chill. By this arrangement each plug or pellet of active material is part and parcel of the four surrounding ones, and, moreover, instead of the plug being in contact with the lead grid only round the four sides of the square, it is in contact with the back of the square in the other half of the chill.

It is by thoroughly investigating and studying these points that improvements are made, and I think a very much larger proportion of the active material in these batteries will eventually be really useful. Only about 15 or 20 per cent. of the theoretical energy contained in the peroxide is used in practical work, though this has been exceeded in laboratory experiments.

This tracing represents a cell of the same type, but of rather different construction. It is the latest pattern cell manufactured to the requirements of Messrs. Drake and Gorham, by Messrs. Elwell-Parker, of Wolverhampton. [Large cell and unpasted grids, with burred edges, shown.] The following figures, which are the results of some tests I took with some of these cells, may be of interest. The cells tested were two taken from a set of 31 L plate cells which had been in daily work for about 12 months, and were taken at random from the set, no trouble being taken to select them. The cells were fully charged to a gassing state, and were then discharged at the rate of 116 amperes for the two cells in parallel, or 58 amperes per cell. The internal resistance was ·00043 for the two cells. The discharge was continued without any stoppage for 16 hours, at the end of which time the E.M.F. had fallen 10 per cent., and the current to 109 amperes, or only 6 per cent. The internal resistance was ·00073. The capacity of the discharge was 1,860 ampere-hours, or 930 per cell. The cells were then recharged at an average rate of 90 amperes, and the efficiency in ampere-hours was 85 per cent. The capacity of these cells, as given by the makers, is 700 ampere-hours, so that there was an increase of about 30 per cent.

This, I think, speaks for itself, and shows that secondary batteries have reached a fair state of efficiency in practical work. A much higher efficiency would have been obtained if the cells had been discharged at a lower rate, but the test was made with the maximum rate of charge and discharge given by the manufacturers, and without a single stoppage in the discharge. The efficiency of a secondary battery increases as the rate of discharge is decreased, and when a cell is discharged at a very slow rate, nearly 100 per cent. efficiency in ampere-hours can be obtained, though, of course, this is useless for practical work.

Among the recent improvements in these cells, the following points may be noticed. The patent method of "burring" over the edges of the grid by which the plugs of active material are securely held in their places. This is done in a very ingenious way by means of a special tool, consisting of a number of discs fixed on a spindle. This spindle revolves very rapidly, and presses on the longitudinal bars of the grid, spreading the same out over the active material till the section of the grid is this shape. This rolling also tends to make the grids denser, thereby making them more durable.

Another important improvement is the patent method of supporting the anodes. When a plate buckles it always commences at the edges, so it was decided to hold the plates by the edge only and leave them entirely free in other ways. To do this, little lugs were cast on the edges, and these lugs fit into an ebonite frame, which is bolted to the negative plate and entirely supports the positive plates, the support being given where the buckling commences. By the arrangement of these lugs it is impossible for any oxide to lodge and form a short circuit between the plates. Only one separator is used with this method of holding the plates; this is a great advantage, as it allows the electrolyte to circulate freely. If the circulation of the electrolyte is bad in charging, the acid gets denser at the bottom of the cell. This is very bad, as a cell will very soon get into a bad condition if the density of the electrolyte varies in different parts of the cell. In the Tatham battery the objects aimed at are to utilise more of the active material to give a high rate of discharge, and to prevent the active material from disintegrating. This is done by mixing wood pulp with the oxide of lead to make it more porous, thus exposing more surface of active material to the electrolyte. I believe these cells have given very good results, although they are not in general use at the present time. [Plates shown.] There are other ways of doing this, one very good way being to mix the oxide into a paste with a solution of some salt, which evaporates when the plate is dry, or to mix a salt itself with the oxide, which will dissolve when the plate is put into the electrolyte. Care must be taken that too much porosity is not obtained, or the active material very soon disintegrates.

The Reckenzaun plate is constructed in a novel manner, the active material being moulded into little cylinders, and the lead frame is cast round them. (There is a sample plate on the table.) These plates are very strong, and can be bent into a cylinder without hurting them; the two here have been dropped on the floor, and are none the worse for it. There is a new cell being introduced in America, which is constructed on rather new lines, and which seems to be making a considerable stir there [cell shown]. The active material, instead of being pasted on is poured on to the lead-supporting frame in a molten state, and, it is said, is fused to it so well that the line of demarcation between frame and active material is hardly discernible. (Whether this is so or not time and work alone will show, as many secondary batteries work well for the first few months and then fail, no tests of secondary batteries are really conclusive unless carried on for 12 or 18 months at least.) The idea seems good, and if it can be carried out should produce a cell which will stand more than the ordinary amount of hard work and knocking about. The general arrangement of the cell is not so good as our English cells. For example: The negatives are connected to the metal box, while the positive plates are connected to the metal lid, a thin strip of wood keeping the lid from shutting closely on to the box. The cells are connected up in series by standing one box on the top of the other, so that the box of one cell is connected to the lid of the other. This, I believe, is considered to be a great improvement by the Americans; but I think when they have had as much experience in the maintenance of secondary batteries as we have, they will rather modify their opinion. There is another cell, about which a great stir was made in England about two years ago, which hardly belongs to either of the two classes. I refer to the Union, or lithanode cell. In this plate, as you see, the active material supports itself, and contact for charge and discharge is made through a platinum strip. [Plates shown.] This plate would undoubtedly be a great improvement on the other types of cells if its working capabilities were as good, and it is quite worthy of a little consideration, as it is certainly the nearest approach to a theoretically perfect cell that we have here to-night.

(To be continued.)

LONDON CHAMBER OF COMMERCE.

The following is the report of the Sub-Committee on Railway Rates:

To the Committee of the Electrical Trades Section of the London Chamber of Commerce.

GENTLEMEN,—We have carefully considered the provisions of the Railway and Canal Traffic Act, 1888, and have examined most of the proposed classifications of merchandise traffic, and schedules of maximum rates and charges submitted to the Board of Trade by the various railway companies in pursuance of the provisions of the above Act. We have also carefully compared these proposed classifications, in so far as they affect goods with which the electrical industry is concerned with the railway clearing house general classification of goods at present in force. The schedule to this report contains a comparative statement of the existing and proposed classifications of such goods.

The proposed revised classifications were submitted by the railway companies to the Board of Trade in February last, and the Board of Trade have extended the time for receiving notices of objections till 9th June next.

The category in which an article is placed determines the rate at which it is to be conveyed, and hitherto a revision of a rate was obtainable by a transfer of the article from one class to another. The classification to be made by the Board of Trade will, however, be permanent, and will be unalterable when once adopted by Parliament, except by a new Act.

With certain exceptions the revised schedules adopt the clearing house classifications. The signs have, however, been varied.

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Class M (a) of clearing house corresponds to Class A of revised classification.

Class M (b) of clearing house corresponds to Class B of revised classification.

Class S of clearing house corresponds to Class C of revised classification (special class).

Class I of clearing house corresponds to Class I of revised classification.

Class 2 of clearing house corresponds to Class 2 of revised classification.

Class 3 of clearing house corresponds to Class 3 of revised classification.

Class 4 of clearing house corresponds to Class 4 of revised classification.

Class 5 of clearing house corresponds to Class 5 of revised classification.

Classes A and B are not of special interest to the electrical trades.

The classification in Class C applies only to quantities of two tons or upwards; if goods in Class C are sent in consignment of less than two tons, they are subject to the maximum and terminal charges in Class I.

The rates in Classes 1 to 5 apply to quantities exceeding 560lb., an increase of 60lb. on the minimum usually fixed in the existing Acts.

Insomuch as all the railway companies, whose proposed classifications we have examined, have adopted a common classification, we do not think it necessary in the annexed comparative statement of existing and proposed classification to do more than mention one company—the London and North-Western Railway Company.

Upon reference to the annexed schedule, it will be observed that the most serious variation in the proposed classification is the *entire omission* of the item "Dynamos and Electric Machinery," which, as the result of much effort, it will be remembered, was some time back transferred into Class 3, when not packed, and Class 2 when in cases. The effect of this omission might be that electric machinery might be classed either under "machines fitted up or partly fitted up not otherwise provided for," not packed, Class 4, packed Class 3, or under Class 5, the highest category, by being brought under the general definition of "all articles, matter, and things not hereinbefore classified."

Although this is the most important objection to the proposed classification, which in our opinion should be strongly raised in the interest of the whole industry, there are no doubt several other modifications which can be shown to be unjust and unreasonable.

The classifications call for the most careful consideration of the various branches of the industry, but care should be taken not to multiply needlessly the objections to be raised. For instance, although "storage batteries" have been removed from Class 2 to Class 3, they can still be conveyed at Class 2 rates by being declared as "electric accumulators."

Other objections, again, as that to the placing of empties in Class 5, will no doubt be made by the chamber on behalf of all trades.

There are a variety of other questions arising out of the provisions of the new Act, and of the proposed schedules of maximum rates and charges, and of the general conditions submitted by the railway companies, which merit the attention of manufacturers and traders in the country—*e.g.*, the general conditions which are proposed by the companies to govern the traffic, the question of terminal charges, the rates for small parcels, etc., but as these are not of special concern to the electrical industry, we recommend that the Electrical Trades Section should in these matters act in concert with the other sections of the chamber.

It would be well, however, for every member of the Electrical Trades Section to obtain the proposals of the railway company or railway companies of his district and examine and report on such questions as the selection of "large town" and "terminal stations," which have an important bearing upon the charges the companies will be entitled to make in respect of services before and after conveyance by rail.—Yours, etc.

Members of the section are requested to send in any additional facts, interesting to the trade, to the Secretary of the Chamber of Commerce, Botolph House, Eastcheap, E.C.

Schedule of Existing and Proposed Classifications in so far as they affect Goods appertaining to the Electrical Industry.

Description of Article.	Existing Classification.	Proposed Classification.
Acid, sulphuric	Under 2 tons in the carboys double 4.	—
Accumulators, electric...	2	2
Angle-plates, steel	For less than 2 tons. } 1st	2 tons up. C. Less 1.
,, ,, ...	Over special.	
Asbest s	2	—
Bar iron	For less than 2 tons. 1	Less 1.
	Over 2 tons special.	2 tons up. C.
,, puddled	10% over rates for pig iron.	2 tons up. C. Less 1.
Bars, angle iron or steel	S	2 tons up. C. Less 1.
Bundles of bars—		
Under 5ft. 8in.	1	1
Over 5ft. 8in...	S	
Capstan	1	1
Cast iron..................	1	1
Batteries, telegraph	3	—
,, electric storage	2	3
Bedplates, engine.........	S	2 tons up. C. Less 1.
Beds and cylinders	1	1
Belting, leather............	3	3
Boiler fittings, except locomotive, and not accompanying the boiler	2	2
Boilers, less than 1 ton, occupying one waggon	2	
Under 30ft................	1	
Above 30ft. and under 45ft.	2	2
Above 45ft.	3	
Bolts and nuts, iron......	S	2 tons and up. C. Less 1.
Brass	2	2
Bronze (phosphor).........		
Castings and ingot rough	2	2
Cable	4	4
Carbons	3	3
Canvas belting	3	3
Carboys, not glass, empty, not returned	4	—
Ditto, glass, empty	3	—
Cardboard	1	3
Cardboard boxes, packed, except in cases	4	—
Ditto, in cases	3	—
Cars, tramway	Up to 20 miles 3d. ton p.m. 2/- ton added. 21-22 miles 7/- ton 23-34 ,, 2½d. ,, p.m. 2/- ton added. 35-38 miles 10/ ton 39-40 ,, 2½d. ,, p.m. 2/- ton added 41-54 miles 11/- ton 55 miles and up 2d. ton p.m. 2/- ton added.	—
Chandeliers and gasoliers	5	5
Castings, brass	3	3
,, crank, unfinished	S	—
,, steel	3	2 and 3
,, rough and unfinished.........	1	1
,, iron, malleable..	1	2
,, iron, light, packed	1	2 also 3
Cement	S	Blocks or slabs 4 tons up. B and C 2 tons up. Less class 1.
Cement and concrete......	MB	Ditto.
Cement and composition for retaining heat in boilers, in casks, cases, or bags	S	—
Cement, patent metallic.	S	—
Chains, unpacked	S	2 tons up. C. Less 1.
,, packed	S	2
China, in boxes or cases.	4	
,, casks or crates	2	5
,, hampers	3	
Cisterns, cast iron..	2	4
Cisterns and tanks, iron or wooden (not lined with lead)	2	4
Cisterns, wood and lead lined	3	—
Coal.............	MA	4 tons up. A. 2 ,, C. Less 1.
Copper	2	2
Cordage	2	2 ropes
Cotton waste	2	2
Cotton and linen goods in bales, boxes, cases, or trusses	3	3
Coupling boxes	S	—
Crucibles	By	Class 2, also 5. 2 tons up. C. Less 1.
Cullett	S	—
Delta metal	2	3
Disincrusting fluid	2	—

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Description of Article.	Existing Classification.	Proposed Classification.
Dynamos and electric machinery, not packed	3y	—
,, in cases ...	2	—
Ebonite or vulcanite... ..	3	—
Engines, caloric....	2	—
Engines, portable— lots of over 2 tons... ,, less 2 tons 47	Up to 20 miles 3d. ton p.m. 2/- ton added. 21 to 22 miles. 7/- ton. 23 to 34 ,, 2¼d. ton p.m. 2/ ton added. 35 to 36 miles, 10/- ton. 39 to 40 ,, 2½d. ton p.m. 2/- ton added. 41 to 54 miles 11/- ton. 55 and up, 2d. ton p.m. and 2/- added.	2
Empties, returned, and from original consignee to original sender	Not exceeding 25 miles 6d. per cwt. 26 to 50 miles, 8d. 51 to 100 ,, 1/- 101 to 150 ,, 1/3 151 to 200 ,, 1/6 201 to 250 ,, 1/9 251 to 300 ,, 2/- 301 to 400 ,, 2/3 401 to 500 ,, 2/6 501 to 600 ,, 3/-	5
Engines, steam	less 3 tons 3	2
,, gas	2	2
Fibre, vulcanised	3	—
Files	2	2
Firebricks	MB	B
Fireboxes of steam-eng's	2	—
Fittings, illumination ...	3	gasfittings 3 iron
Flywheels and spurwheels not requiring special vehicle—finished	1	—
at 6s. risk ...	1	—
unfinished ..	S	—
Forgings, iron or steel, in the rough	S	2 tons and up. C. Less Class 1.
Frames, almanac, in pieces, packed	3	—
Frames, street lamp......	3	3
Furnace boilers	2_7	—
Globes, moons, and shades.....................	4_7	5
Insulators, electric	2	2
Mirrors, and packed......	5	—
Glycerine—		
In glass carboys, packed	5	Casks or iron drums 5
Ditto not packed, O/K	5	3
Gunmetal	2	2
Heaters, expanding— Feed water..............	As boilers.	—
Hoop iron or steel.........	1	1
Hoops, iron in the rough	S	2 tons up. C. Less 1.
Hydraulic machinery ...	1	1
Insulators, telegraph— Packed	1	—
Iron, blooms, billets, and ingots— Not foreign	10 % over rates for pig iron.	2 tons and up. C. Under 1.
Foreign iron	MB	Lots 4 tons & up. B ,, 2 ,, & ,, C
Pig iron	MB	,, under 1.
,, foreign...........	10s. over rates for British pig.	—
Iron, sheet or plate, annealed......	1	—
Irons, tue (or tuyeres)...	2	3
Lamp posts, iron	1	1
Lamp reflectors, enamelled iron...	3	3
Lamps, except paraffin...	4	4
Litharge	1	1
Machines, fitted up or partly fitted up, not otherwise provided for, not packed...............	4	4
Packed	3	3
Meters, gas.....	3	3
,, water................	3_7	3
Mouldings, common wood	3_7	—
Oils, castor, lubricating, in cases	1	2 also 4.
Oils and varnish tins ...	3	Oils 2 ,, 4.
Packing piston	2	—
Patterns, travellers', except china, plated goods, and goods chargeable 5th Class rate—		
Packed in boxes ...		
Cases, parcels, or hampers......... ..	4	

Description of Article.	Existing Classification.	Proposed Classification.
Paints and colours—		
In cans, hampers	3	In jars 5.
Casks or drums...	2	2
Tins, packed cases ...	2	Also 3
Paper, bales or bundles..	1	—
Boxes or cases	3	3
Patterns, wood	4_7	4
Pipes, brass or copper ...	4	4
Pipes, cast iron or steel, 2 tons and upwards...	1	1
less lots	1_7	
Posts, iron for wire fencing and street boundary posts.................	S	2 tons and up. C. Less Class 1.
Posts, lamp iron	1	1
,, signal	2	—
,, telegraph	1	—
Pulleys, iron	3	3
Reflectors, glass, with metal backs	4	5
Ropes, not new wire......	2	2
,, wire, new	2_7	—
,, ,, old	S	—
Salammoniac	2	2
Screwing machines	1	1
Shaping ,, ...	1	1
Sheet iron, in bundles not packed..............	1	1
Sheet steel	3_7	3
Sheet or iron plated, annealed........	1	1
Shellac	3	3
Solder........................	1	1
Solderine		—
Spelter or zinc, not packed	S	1
Spelter, sheet..	—	2
Spirit, methylated—		
In hampers	4	Spirits quoted in cases or casks, Class 3; methylated spirits also quoted, Class 5
In casks or cans	3	
In jars or bottles, under 2 gallons......	4	
In ditto over 2 ditto...	5	
Sponge cloths	2	—
Stampings, iron, rough unfinished	1	—
Stampings, shearings, and clippings, in bundles.............	S	—
Steel bars or bolts.........	2	2
Strips, iron, in bundles unpacked	1	—
Tapes	3	—
Taps, brass or wood	3	3
Tar, except belt tar, gas tar, coal tar in casks...	S	—
Telegraph cable............	4_7	4
Telegraph clothing— Post office servants' new	3	3
old	2	
Telegraph instruments...	4	5
,, insulators......	1	—
,, poles at machine weight	S	—
Telegraph posts, iron ...	1	1
Telegraph wire coated with guttapercha, packed or not	4_7	Wire insulated 4
Telegraph Stores, viz.—		
unpacked { W.I. double swivels	1	2 tons and up. C. Less Class 1.
C.I wall brackets ...	1	
C.I. saddles.....	1	
G.I. & Q-looped rods	—	2 tons and up C. Less Class 1.
Stay tighteners, &c.	S	
Pk. Telephone apparatus	4	5
Tinfoil	2	2
Tools, edge.................	3	
Carpenters' and coopers'	3	3
Joiners' and shipwrights'	3	
Tram couplings.....	1	—
Tram wheels	S	—
Tubes—Iron or steel.. ...	1	1
Steam, new	2	2
Steam, old	1	—
Tubing brass or copper...	4	4
Valves, brass	3	3
,, gas & water, iron	1_7	1
Varnish—		
In vessels of bottle shape, iron or tin ...	3	
In cases, packed in cases, or protected with iron hoops......	3	3
In jars protected by wicker work	3	
In casks or iron drums	2	
In glass carboys or tubs	5z	

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Description of Article.	Existing Classification.	Proposed Classification.
Washers, brass or copper	3	3
Iron ditto	S	3 tons up. C. Less 1.
Leather	2	2
Wire—		
Copper or brass, packed in casks, cases or bags..................	3	3
Cotton covered, packed	2	Insulated? 4
German silver	3	—
Iron......................	2z	1 and 2.
,, undamageable ...	S	2 tons up. C. Less 1.
,, dipped in a solution of copper ...	3	3

COMPANIES' MEETINGS.

NEWCASTLE ELECTRIC LIGHTING COMPANY.

On Monday the first general meeting of the Newcastle and District Electric Lighting Company, Limited, was held in the County Hotel, Newcastle, to receive the report of the Directors as to the progress of the Company, and to transact the other ordinary business of the Company. On the motion of Sir Benjamin Browne, seconded by the Hon. C. Parsons, Mr. J. D. Milburn was voted to the chair.

The **Chairman** said that was a meeting which they were obliged to have under the Act, which enjoined that a general meeting of the Company should be held within four months of its registration, and it was customary on these occasions to give the shareholders a report of the progress of the work in such cases where no business of the Company had as yet been undertaken. As it was necessary to consult the local authority, and to get its permission to acquiesce in the establishment of the Company, they had very little trouble with them. They had then to make application to the Board of Trade, and to give notice for two months in order that anybody objecting to the establishment of the Company might give notice of opposition. The time for the notice would expire on the 26th inst., and, as far as the Directors knew, there was absolutely no opposition. They expected, therefore, by the end of the month, or the beginning of next, to have the sanction of the Board of Trade and its license to commence work. The Directors had been able to make several important contracts. The dynamos and engines had been partly contracted for, and he believed they could all be ready almost immediately. Then all the boilers required for the first section of the work of the Company had been contracted for, and would be delivered at the end of June or in July. The Company had, after careful consideration, chosen a site for the central station at Forth Banks, and as soon as the Board of Trade license had been received the seatings for the boilers would be commenced with, the erection of chimneys proceeded with, and the Company would begin to lay the cables in order to supply the current to customers. The system of lighting adopted by the Company, after mature and careful consideration, was that of the moderate tension of 1,000 volts alternating currents, and it was thought that this system, which was pretty well used, and which was pretty familiar to most electric lighting companies, would be such as to give the consumer an excellent, steady light. The Company not only pretended to light Newcastle, but it had powers to light the district, and might have to adopt a higher tension—something like 2,400 volts alternating current, or even more—and under these circumstances the Directors had held it wise and judicious to lay such cables and such transformers as would carry the higher voltage. Some of their electric lighting friends in London were adopting these higher tensions, and the Company would have the benefit of their experience in that direction. At present the Company was going upon what might be called safe lines, and was adopting what was considered to be a very safe voltage, and one well within control. The machines adopted were those of the turbine system, well known in this district. It had been applied to several works, and also to a great number of steamships, and had given very great satisfaction. These engines had been ordered from Messrs. Clarke, Chapman, and Parsons, and were being constructed with the very greatest care, and he had no doubt they would give every satisfaction to the Company. The boilers, which were three in number, and of the high pressure of 140lb. to the square inch, were being made by Messrs. R. and W. Hawthorn, Leslie, and Co. in their works adjoining the Company's station at Forth Banks, and it had been a very particular care of the Directors to have more boiler power even than was necessary for the first section. So much for the work which had been going on in the way of erections. With regard to the business operations of the Company, the business staff of the Company had not been idle. They had been canvassing, and at the present they had signed applications for lighting amounting to 35,000 c.p. incandescent light, or 3,500 lamps of 10 c.p., which was about half the trade required to keep the first section fully going. They were daily increasing their connection, and now that the tradesmen and others likely to make use of the light saw that the Company was in earnest, and setting about its work in a business-like way, they gave their proposals very careful consideration, and the Directors believed the result would be that in a very short time there would be more business than the first section of the work would be able to undertake. The Directors were determined upon two or three points. The first was they were resolved to give a good and steady light; the second was they were going to ask a fair and sufficient price for it. There had been several electric companies which had come to utter failure, and for that he believed there were three reasons. The first was the heavy initial expenses; the second was the injudicious selection of machinery, plant, etc., and the third was the working at a price totally inadequate to the work. There must be a great many unknown elements in such a new thing as the electric light. And some of those companies had an absurd and Quixotic idea of entering into a war to the death with gas. That Company did not entertain any such notion. What they proposed to do was to give a light of a higher order than gas, at a higher price. But it was a matter of calculation whether that price would really be higher or not. Gas was often used in a manner utterly wasteful, and that waste was avoided in the use of the electric light. The Company intended to provide a brilliant and better light than gas—an innocuous and exhilarating and artistic light, altogether out of the reach of gas. The electric light would be an advantage in concert-halls, ballrooms, picture galleries, and a source of safety in places where delicate fabrics were stored, and that by reason of its incandescence, and absence of heat, and more especially by reason of the utter absence of the innocuous element allowing the air to be entirely unvitiated. They hoped, with the system they had adopted, they would be able to give an unvaried and splendid light at all times. And in doing that they were much in sympathy with the consumers, who did not want to have the light for the sake of saying they had it, but who wanted a first-class light. One of the first towns to adopt the electric light on a large scale was Milan, in Italy, where, not only was it in general use in shops, hotels, and private houses, but it had become the sole illuminant of the streets. The light in Milan had been supplied publicly for upwards of six years, and had given the greatest satisfaction. Since Milan started operations, all the great European capitals and a large proportion of the provincial towns had now almost, as a matter of course, their central electric lighting stations. In Paris and Madrid laws had even been passed prohibiting the opening of any theatre not fitted throughout with the electric light. Eighteen towns in Spain had adopted the new illuminant, and as many, if not more, in Italy had followed the same course. In America the advance made in electric lighting had been very rapid, nearly all the great cities taking to the new illuminant in a wholesale way both for street and interior lighting. The Electric Company of Berlin were now running 36,000 lamps of 16 c.p. each, at a charge of 9½d. a unit of 1,000 watt-hours, the dividend being 7½ per cent. last year. In special districts 800 or 900 lamp-hours per annum were used, and in residences 400 to 500 lamp-hours per annum. In Milan the streets were lighted by 350 arc lamps. Each lamp would be equal in illuminating power to about 50 of the street lamps in this town. The lamps were hung over the centre of the streets on wires stretched from house to house. The illumination of the streets was perfect, and added greatly to the attractiveness of the town. In Rome about 13,000 10-c.p. lamps and 200 arc lamps were being run at present, some of the lights being three miles distant from the generating station. Plant for about 36,000 lamps was in course of erection. Electricity in the form of motive power, as applied to traction, had already established for itself a firm footing in America. Tramway companies were making a most extensive use of the electric current for driving their cars. Electric cranes, lifts, hoists and motors were now largely used in factories and warehouses where the electric light was installed. Small electric motors had been fitted to sewing-machines on a large scale in important manufacturing establishments in the States. Bleaching, welding of metals, and aluminium process, were other applications and examples of the wonderful adaptability of electricity to meet everyday wants. And now, looking at things at home, they found great electric generating stations springing up all over London, and the demand for the electric light is rapidly increasing. The price the company intended to charge was 5s. for 10,000 watt-hours, or 6d. per Board of Trade unit, with discount to consumers according to the quantity of light taken. They had now something like 29 or 30 applicants for the light, some of whom had already begun to have wires laid on to their premises. The Directors had every confidence in the successful working of the Company, and did not fear anything about capital. The difficulty hereafter would be to refuse capital. The nominal capital was £50,000 in 5,000 shares of £10, and it was only proposed to issue 2,000 at present.

An extraordinary meeting was subsequently held, at which **Mr. Findley** moved the adoption of the articles of association.

Sir Benjamin Browne seconded the motion.

Mr. Angus supported the motion, which was put to the meeting and carried.

A vote of thanks to the Chairman ended the meeting.

NEW COMPANIES REGISTERED.

Crompton-Howell Electrical Storage Company, Limited.—Registered by Mackrell, Maton, and Godlee, 21, Cannon-street, E.C., with a capital of £19,600 in six founders' shares of £100 and 19,000 ordinary shares of £1 each. Object: to carry on the manufacture and sale of secondary batteries, and to take over the business of the Crompton-Howell Electrical Storage Company. The first subscribers are:

	Shares
J. Albright, Mansion House-buildings, E.C.	1
J. C. Howell, Caeffrain, Llanelly	1
H. Laurence, 29, Grove-hill-road, S.E.	1
G. Hartmans, 2, Hartington-road, Ealing	1
H. Dowsing, 4, Queen Victoria-street, E.C.	1
F. Reeves, Springfield, Potter's Bar	1
L. Maton, 21, Cannon-street, E.C.	1

The number of Directors shall not be less than four nor more than seven The first are R. E. B. Crompton, W. Albright, G. Albright

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J. Albright, and J. C. Howell. Qualification, £500 shares. Remuneration, £50 per annum each.

Keswick Electric Light Company, Limited.—Registered by Waterlow Bros. and Layton, Limited, 24 and 25, Birchin-lane, E.C., with a capital of £5,000, in £1 shares. Object: to carry on at Keswick the business of electric light manufacturers. Registered without articles of association, and, consequently, the regulations of table A in the first schedule to the Companies Act, 1862, apply.

Mexican Southern Railway, Limited.—Registered by Ashurst, Morris, Crisp, and Co., 6, Old Jery, E.C., with a capital of £1,000,000 in £10 shares. Object: to construct or acquire and equip, maintain and work railways, tramways, lines of telegraphs, telephones, or other means of communication or appliances of a similar nature in the Republic of Mexico; to acquire mining powers, rights or easements over any railway, tramway, or line of electric wire; to carry on the business of carriers of passengers and goods in all its branches by land and water, and that of transmitters of messages. The first subscribers are:

	Shares.
E. H. Clarke, Bartholomew House, E.C.	1
Lord Norreys, 3, Lowndes-street, S.W.	1
B. L. Rose, 1, Cromwell-road	1
T. H. Weguelin, 31, Sackville-street, W.	1
W. White, 10, Waughton-road, Anerley	1
W. Adams, 168, Friern-road, Dulwich	1
G. Lucas, 80, Bartholomew-road, N.W.	1

The number of Directors shall not be less than three nor more than nine; the first to be appointed by the subscribers to the memorandum of association. Qualification, £250 stock. Remuneration: Chairman, £1,000; other Directors, £400 per annum.

Medical Battery Company, Limited.—Registered by C. Doubble, 14, Serjeants'-inn, Temple, E.C., with a capital of £100,000 in £5 shares. Object: to acquire the business, goodwill, rights, privileges, contracts, copyrights, trade marks, patents, assets and property of whatever class now possessed by the Medical Battery Company, Limited, and to carry out an agreement made between C. B. Harness, the liquidator thereof, and H. C. R. Sharman, trustee for the new company. The first subscribers are:

	Shares.
Major C. G. Elers, Crewkerne	1
W. de Lorne, 34, Sidney-road, Stockwell	1
C. B. Harness, Potter's Bar	1
E. Crick, Montrose-road, Putney	1
A. Fleet, 39, Hatton-garden, E.C.	1
G. Wills, Crewkerne	1
R. Moffatt, Northumberland-park	1

The number of Directors shall not be less than three nor more than seven. The first are the present Directors of the Medical Battery Company, Limited; C. B. Harness is apppointed managing director. Remuneration, £1,000 per annum. The Directors, including the Managing Director, are to receive 5 per cent. on the net divided profits, to be divided as they determine.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The traffic receipts of this company for the week ended April 3 amounted to £2,844, and for the week ended April 10 to £3,086.

Submarine Cables Trust.—The report of the Submarine Cables Trust for the financial year to April 15 states that the revenue, including the balance brought forward, amounted to £20,567. The coupon due on April 15, 1888, was paid in two instalments—viz., £2. 10s. on October 15, and the balance of 10s. on November 15 last; £2. 12s. 6d. of the coupon due October 15, 1888, was paid on April 15 last. The balance of 7s. 6d. was paid on the 15th inst. The expenses amounted to £1,384, and the payments on account of the coupons to £19,018, leaving £165 to be carried forward.

Western and Brazilian Telegraph Company, Limited.—This Company, in their report for the half-year ended December 31, state that the total earnings amounted to £112,250, against £78,369, and the working expenses to £31,220, against £30,903. The Directors recommend a final dividend of 9s. per share, tax free, on the ordinary shares, making with the dividend paid in November, 5 per cent. for the year. The dividend for the year 1887 was at the rate of 4¼ per cent. per annum. In the case of shares which have been divided into preferred and deferred, 1s. 6d. per share of the dividend now recommended will be payable to the preferred shareholders, and 7s. 6d. per share to the deferred shareholders. The balance remaining is £29,561. The traffic receipts of the Company for the fortnight ended May 10, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £4,086.

PROVISIONAL PATENTS, 1889.

MAY 6.

7522. **An electric ignition for gas, petroleum, oil, or combustible vapour motor engines.** Herbert Sumner, 29, Dundonald-road, Kilmarnock.

7526. **An automatic compensating feed electric arc lamp.** Alfred Upton Alcock and Henri Galopin, 70, Market-street, Manchester. (Complete specification.)

7568. **Improvements relating to electric batteries.** George Horatio Jones, Southampton-buildings, Middlesex.

MAY 7.

7597. **Dry galvanic cells.** Carl Hermann Mehner, 15, Water-street, Liverpool. (Complete specification.)

7600. **Improvements in electric indicators.** Benjamin Charles Cross Cant, 73, Pembroke-road, Walthamstow, Essex.

7613. **A new boat, which shall be here called "The over-water boat, for steam, hot air, electric, or any other motive power or mode of propulsion."** Stephen Price, 33, Union-road, Newington-causeway, and Charles August Soderberg, 199, Southwark-bridge-road, London.

7619. **Improvements in and connected with electric batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

7645. **Improvements in underground conduits for electrical conductors.** George Washington Cook, 45, Southampton-buildings, London. (Complete specification.)

7647. **Improvements in electric motors and dynamo-electric machines.** Schuyler Skaats Wheeler, 46, Lincoln's-inn-fields, London. (Complete specification.)

MAY 8.

7673. **Improvements in electric wire insulators.** Arthur West Heaviside, 7, Grafton-road, Whitley, Newcastle-upon-Tyne. (Complete specification.)

7719. **Improvements in electric or galvanic elements or cells.** Paul Schoop, 46, Lincoln's-inn-fields, London.

MAY 9.

7773. **Improvements in means for actuating signals, switches, and gates on electric and other railways.** Robert Cooke Sayer, 11, Clyde-road, Redland, Bristol.

7774. **Improvements in means for supplying electric current to road vehicles, boats, and the like.** Robert Cooke Sayer, 11, Clyde-road, Redland, Bristol.

7780. **An electrical-firing apparatus for ordnance.** Richard Morris, 28, Southampton-buildings, Chancery-lane, London.

7796. **Improvements in supporting electric conductors.** Wm. Arthur Smith Benson, 24, Southampton-buildings, London.

MAY 10.

7808. **An electrical alarum and valve attachment to gauges (pressure, vacuum, speed or other gauges).** Arthur Julian, Church-street, Basingstoke.

7810. **Improvements in electrical instruments.** William Henry Douglas and Thomas Hugh Parker, 7, Cherry-street, Birmingham.

7856. **Improvements in electrical transformers.** William Claude Johnson and Samuel Edmund Phillips, 28, Southampton-buildings, Chancery-lane, London.

7860. **Improvements in holders for electric incandescent lamps.** Sydney Pitt, 24, Southampton-buildings, London. (Charles Lemon, New Zealand.)

MAY 11.

7868. **Improvements in electric meters.** Walter Emmott, Square-road, Halifax, and William Ackroyd, Royal Insurance Buildings, Halifax.

7870. **An improved electric generator.** Joseph Gozo, 41, George-street, Portman-square, London.

7883. **Improvements in electro motors and apparatus used therewith for dental and other purposes.** Thomas Cuttriss, 72, New Briggate.

7894. **Improvements in the method of distributing electricity by means of alternating currents.** Llewelyn B. Atkinson, Woodfield-road, Harrow-road.

7895. **Improvements in dynamos, motors, and motor-generators for use with alternating currents.** Llewelyn B. Atkinson, Woodfield-road, Harrow-road.

SPECIFICATIONS PUBLISHED

1888.

8809. **Electric switches.** Lake (Bergmann.) 8d.

8905. **Electric batteries.** Lahousse and Co. and Collé. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	18
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply ...	5	3¾
......	...	Swan United	3½	2¾
12 July	12/0	Telegraph Construction ...	12	42
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15¼

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NOTES.

Westinghouse in London.—The Westinghouse Electric Company have taken offices in Gresham-buildings.

Lighting the Vestries.—St. Martin's Vestry Hall is now lighted by electricity, the result being an unqualified success.

Civil Engineers.—Sir William Thomson and Sir Henry Bessemer have been elected honorary members of the Institution of Civil Engineers.

The Institution.—The discussion of the paper by Mr. Mordey, "On Alternate Current Working," before the Institution of Electrical Engineers, will take place next Thursday, May 30th.

Telpher Lines.—The United Electrical Engineering Company are actively engaged upon a new telpher line at East Pool, near Truro, for the transportation of tin. The length of the line is about 1½ miles.

Electric Welding.—The Thomson Electric Welding Company are reported as being overcrowded with orders, and work is being pushed forward with great energy at their factory at Lynn, U.S. It is expected they will shortly have to increase their premises.

Overhead Wires.—It is curious to find that while New York is insisting upon all overhead wires being taken down, at Boston, U.S., authority has been granted for the introduction into the heart of the city of the overhead wire system for the Thomson-Houston electric cars.

Society of Arts.—A paper will be read before the Society of Arts next Tuesday at 8 p.m., on "The Westinghouse Alternating System of Central Station Electric Lighting in the United States of America," by James S. Humbird. The chair will be taken by W. H. Preece, F.R.S

Old Students' Conversazione.—The conversazione of the Old Students' Association with exhibition of instruments and apparatus at the Finsbury Technical College, which opened yesterday, will continue this (Friday) evening, for visitors wishing to inspect the college and exhibits.

Ship Lighting.—Amongst the ships recently fitted with the electric light by Messrs. Paterson and Cooper are the screw steamers "Islander," Curfew," "Ardle," "Dundee," "Cambria," "Pladda," "Dean," "Modjeska," and the steam yacht "Tighnamara." The firm has several ships in hand being fitted up.

Windsor.—At the Windsor Town Council an application was considered from the Windsor and Eton Electric Lighting Company for lighting powers within the borough, and was referred for consideration to a committee composed of members of the Authority who are not interested in the gas company or the proposed electric light company.

Electric Tramcars in Paris.—For some time an electric car has been running in Paris between the Place de la Madeleine and the Levallois gate. Faure-Sellon-Volckmar batteries are used with a Siemens motor. The power is communicated to the wheels by belting, and the motor is capable of exerting 12 h.p. The car is similar in appearance to the ordinary tramcars.

Hastings.—The Hastings Electric Light Company have declared a dividend of 3 per cent., free of income-tax. The company now supply about 1,000 lights, and the directors feel an enormous increase could be at once made if sufficient capital was available for laying down new mains, and they are not without hope that arrangements can be made by which public and private lighting from this station can be vastly extended.

St. Helen Tramways.—Mr. John Waugh, of Bradford, has purchased for the sum of £23,000 the whole of the plant and outfit of the St. Helen Tramways, which ten years ago cost £87,500. There are 10 miles of tramway, 75 horses, and 25 cars. Possibly Mr. Waugh appreciates the earning power of electricity, and is intending to substitute his 75 horses by accumulators. There is evidently a good chance at St. Helens to regain lost ground in tramway work.

Magneto Morse Sounder.—Mr. Campbell Swinton has recently constructed a magneto Morse sounder, on the principle of his well-known magneto bell. The play of the transmitting lever is made less, and the bell hammer is made to hit against two buffers, arranged to give different notes when struck. The absence of battery will make the magneto sounder exceedingly useful for field telegraphing, and the instrument has been sent to the War Department at Chatham to test.

Liverpool Music-Hall.—The extraordinary commercial success of the Empire and the Alhambra Music-halls in London, has led the proprietors of the Alexandra Theatre and Opera House, at Liverpool, to bring out a scheme for converting this place into a Liverpool Empire Theatre of Varieties. Structural alterations will be made to enable the premises to accommodate between 3,000 and 4,000 people, and the electric light plant and fittings will be correspondingly extended.

Leeds.—At the meeting of the Electric Lighting Committe of the Leeds Corporation last Friday, Mr. Howson, the borough engineer, reported that two estimates had been received for lighting the central district of the town. The borough engineer was directed to make further enquiries as to the outlay and likelihood of obtaining customers, and to report to a future meeting. The committee wish to act with the desire of thoroughly safeguarding the interests of the ratepayers.

Electric Street Railways in America.—Our esteemed New York namesake gives a list of the electric railways now in operation or in progress in America, from which we gather that there are now a total of 69 roads with a length of 346 miles, running 512 cars now in operation, while there are constructing or under contract 45 roads with a total length of 202 miles, with 360 motor cars. This is a splendid showing for the progress of electric traction in the States.

An Experimental Club.—A gentleman who has a comfortable electrical laboratory at Wood Green, with a considerable amount of apparatus, writes to us to say that he is desirous of forming a club for the purpose of conducting electrical experiments. He mentions that there are special facilities for conducting static experiments with reference to lightning-rods. Any of our readers who wish to obtain further particulars of the proposed club can leave a note to that effect at our office.

Edison's Iron Process.—A new Jersey company, in which Edison is supposed to be interested, has recently bought a tract of eight acres of iron ore lands. It is said to be the intention of the company to experiment with a

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new electrical process of reducing ore. The proceedings of the company have been shrouded in mystery, and have so excited the curiosity of the residents, that someone broke into the premises and stole all the diagrams relating to the building, evidently hoping to obtain the key to one of Edison's most valuable discoveries.

An Electric Waggonette.—At the Kent County Council, an application was read last week from Mr. Link, of Kent House, Sydenham, asking for permission to run an electric waggonette on the roads in the district. Mr. Low said he ought to go to the London County Council, that being the proper authority for the district mentioned. A member suggested that Mr. Link might want to come into the district under the Kent County Council, and that he be allowed to take out a license for a locomotive, for that was what his "waggonette" really was.

Halifax and Bermuda Cable.—A correspondent writing to the *Financial News* remarks that the advice given in that paper to intending investors to read the agreement with the Government in order to ascertain the conditions under which the subsidy is granted, though, perhaps, not necessary for late investors in the Submarine Telegraph Company, whose property has recently been all but confiscated by the Government, nor to the directors of the new company and their friends, yet to widows and small investors the warning is prophetic. The kind of confiscation which has occurred is described in another note.

Train Lighting on the Midland.—The Midland Railway Company have been making experiments in the electric lighting of trains, and have adopted a system patented by Mr. Langdon, electrical engineer of the company. The dynamo is placed in the rear guard's van, which charges a series of accumulators placed in each carriage. The accumulator contains sufficient for 12 or 14 hours' light, so that the train may be taken to pieces and the light be still available. The light will be used first on the 5 p.m. train from London to Manchester, and other trains will probably also be fitted shortly.

Hull.—A meeting was held last week in Hull to consider the introduction of electric light into that town. The chairman of the meeting (Mr. R. Murray) said there seemed to be a strong feeling against the light due to the unsatisfactory experiments in 1886, when insufficient plant was employed. He put the cost of the necessary plant roughly at about £6,000, and estimated that the cost to consumers might be made less than that of gas. It was eventually decided that the promoters of the scheme should canvass the district it was intended to supply, in order to be in a position to approach the Corporation with a definite proposal.

Technical Education in India.—Lord Ripon's viceroyalty, and the jubilee of the Queen's reign, have together been celebrated in India by the institution of a Jubilee Technical Institute, which has just been opened in Bombay by Lord Reay. The subscriptions of these two funds were supplemented by grants from the Government and the Corporation of Bombay, and devoted to the founding of a technical institute, and Sir Dinshaw Petit presented a noble building. The formal opening, as mentioned, took place recently, although the institute has, in fact, been open for several months. It already numbers 240 students, and nearly half as many more are waiting nomination.

Another Electric Railway Proposed.—On the invitation of some of the leading gentlemen in Brechin, Mr. A. R. Bennett addressed a public meeting in that town on May 16th, on the subject of electric railways, and more especially in connection with a proposed line from Brechin to Edzell, a distance of six miles. There was a large attendance, and the meeting resulted in the appointment of a committee (consisting of Provost Mitchell; Mr. Shiel, factor to the Earl of Dalhousie; Mr. Lamb, manufacturer; Mr. Valentine; Mr. Anderson; and Mr. Philip, Bank of Scotland) to procure estimates and approach the proprietors whose land is required, with the view of avoiding, if possible, the necessity of an Act of Parliament.

The Telephone Amalgamation.—According to the *Financial News*, the arrangement by which the telephone companies will carry out their scheme of amalgamation without the necessity of obtaining the consent of the Post Office authorities is now complete. Instead of forming a new company—a plan which involved a transfer of licenses —the National Telephone Company will purchase the business of the United and the Cheshire Companies by the issue of its own shares to these companies in proportions which are equivalent to those originally proposed. All the licenses, as granted, extend to the whole of the United Kingdom, so that all the department has gained by taking advantage of a technicality has been the satisfaction of delaying the scheme for a few weeks. The amalgamation will take effect as from May 1, and, as merely formal meetings of shareholders are now required, may be said to be concluded.

New York Tenders.—In contemplation of the proposed public lighting of the City of London by arc lights, tenders for which will shortly come before the Commissioners of Sewers, it will doubtless be interesting to compare similar tenders recently received for the lighting of New York. These were as follows: The Brush Company, 441 at 35 cents each a night outside the subway district, and 65 cents where the subways are to be used; the East River Company, 421 lights at 35 cents, and 68 cents in the subway districts; the United States Company, 429 lights at 35 cents; the Harlem, 89 lights at from 35 to 60 cents; the North New York Company, 28 lights at 35 to 60 cents; and the Mount Morris Company, 878 lights at 28 to 55 cents. The latter company at present furnishes only 18 lights, at the rate of 32 cents, and its tender is in competition with the whole of the others with the exception of the North New York.

Recording Voltmeter.—A recording Cardew voltmeter is being made by Messrs. Drake and Gorham, in which the long fine wire inherent to this class of voltmeter is made to go over a series of small pulleys and then acts upon the end of a pointer. This makes the instrument much more compact than the ordinary form. A spring bar takes up the slack, and the readings can be adjusted as desirable. The variations of potential of a battery or circuit can be continuously recorded by passing a strip of lined paper slowly past the pointer. The moving power for feeding the paper will be obtained from an electric pendulum, the impulses from the electromagnet being given about once a minute by a small trailing piece, which catches in a little slot, and touches two contacts together when the swing gets below a certain amplitude. The instrument is likely to prove extremely useful for installations where a record of the electric pressure is required.

Folkestone.—At the last meeting of the Folkestone Town Council, the Electric Lighting Committee brought up a report, which recommended that as the gas company would not accede to the request of the committee to allow

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certain lamps to remain unlighted with gas, the original agreement with Messrs. Crompton should remain the same, except as regarded the date, which should be altered from July 1, 1890, to August 10, 1889, and that they should apply for a license to supply private consumers with the electric light, in which application they should be supported by the Corporation. Also that notice be given to the gas company to discontinue the contract between them and the Corporation on July 1, 1890. After a great deal of discussion, especially as regards the private lighting, the motion was eventually put to the meeting and carried by eight to three. Mr. Thompson then moved that notice of termination of the contract with the gas company on July 1, 1890, be given, and this was also carried.

Liverpool.—The adoption of the electric light in Liverpool is rapidly extending in the business quarters, most of the banks, hotels, theatres, and many business houses being now lighted. Underground conductors have been laid in the principal streets, and the houses already lighted by overhead wires have been connected quietly to the underground mains, and many fresh houses are continually being connected. The overhead wires in most cases are taken down, and other streets, excluded from the first license, are being laid with mains under an extended license received from the Board of Trade, with the consent of the Corporation. The light will be available for the ensuing winter in all the leading business streets, and the three central stations of the Liverpool Electric Supply Company are being extended, and new machinery being put down. We understand that the number of lamps now connected with the company's mains is more than four times the number at this time last year.

Auxiliary Accumulator Cars.—In the case of a tramway proposing to run accumulator cars, but where there is one steep gradient on a long level run, it has been proposed to use an auxiliary electric engine to help the cars up the steep part, as is now the practice with horses. The disadvantages of having very large motors on each car, and of taking an excessive discharge from the batteries, would be obviated. Arrangements for altering the ratio of speed and power by gearing are likely to be far more useful in ordinary cases, but it is possible that circumstances might arise when the adoption of this suggestion would solve a difficulty, and prove more economical, both in maintenance and first cost, than by the adoption of more costly gearing for each car. The passenger cars could then be fitted with light batteries sufficient for ordinary running, and the auxiliary engine would be stationed at the steep part, and be kept working there during the whole day. The saving in outlay for batteries and for gearing might be far more than the cost of the auxiliary engine in a system requiring a large number of cars.

The "O.S.A." Journal.—We have received copies of the first number of the *Journal* of the City and Guilds Institute, Nos. 1, 2, and 3. In these appear some really valuable papers, originally read before the Old Students' Association, some of which we have been pleased enough to publish in this paper. The remaining space of the numbers is taken up with tales and amusing pieces on quasi-scientific subjects, with a number of third-rate jokes and quips which would be better omitted, and the space occupied with subjects more suited to the requirements of a journal catering for the interests of past and present students. The discussion and notes upon the Old Students' meetings, doings, wants, and aspirations, are a far more useful and interesting department, which it would be well to enlarge upon. The *Journal* has a most useful future before it for uniting the forces of the rising technical generation. We wish it all the success it deserves, and hope all old students will subscribe. The *Journal* of the Franklin Institute, now an acknowledged authority, took rise, it may be remembered, in a similar undertaking

Waterproof Moter.—Mr. Sprague some time ago promised a motor whose armature could be washed down with water without injury. Mr. S. D. Greene, of the Sprague Motor Company, New York, reports that they have now accomplished this fact. An armature, after being heated, was allowed to soak in a barrel of fresh water for 24 hours, and upon removal it was tested and found to be perfectly sound. It was then put into a barrel containing a strong saline solution, where it was allowed to remain for another 24 hours. At the expiration of this time it was taken out, and immediately put into a machine and run for two and a-half hours on a load averaging one-third greater than the proper load. The armature at the end of the run was as sound as when the experiment began. Under these circumstances, it must be evident that the armature is exceedingly well protected, and the "delicacy" of this part of the motor practically a thing of the past. The Sprague Company have made arrangements by which this method of waterproofing their motor-armatures can be carried out on a large scale, and in future all their street-car motors will be treated in this way.

Cable Subsidies.—The Chancellor of the Exchequer, in reply to Mr. Henniker Heaton, in the House of Commons on Friday, stated that he had found some difficulty in ascertaining exactly the amount expended on submarine telegrams from England by the various departments of the Government, as the messages do not necessarily pass through the Post Office. Roughly, the total cost of such telegrams in 1888-89 was something under £16,000. Last year's votes show that subsidies amounting to £49,000 net were paid by the Imperial Exchequer to submarine telegraph companies. With reference to the subsidy of the Australian Government to the cable companies, he understood that the Eastern Extension Telegraph Company has laid two cables to Australia. The one which was laid first is unsubsidised, but the Australian colonies pay an annual subsidy of £32,400 for the second. No contribution is made from Imperial finances. He could not say that he was prepared to consider the advisability of appointing a commission to consider and report on the whole question of telegraphic communication between England and the various parts of the empire.

Electric Train Lighting in the Argentine.—The recent terrible accident of the Buenos Ayres and Rosario Railway, where a kerosene lamp set fire to the cars and burnt some of the passengers to death, has caused the Argentine Government to enact that no oil lamps shall be used in passenger cars after May 23 of this year. Before news arrived of the accident, the Central Argentine Railway had already ordered that the electric light should be supplied to a couple of coaches, and had also arranged that the other coaches which were then in construction should be so built that the electric light could be added to them without having to alter the framework of the coach. The cost is about £45 to each Pullman coach. Since that accident occurred, the electric light has been ordered to be applied to half a-

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dozen coaches which were going out to the Northern Railway. The experiment will also be tried of compressed gas as against electric light. The dynamos for generating electricity to light the station at Rosario having become insufficient in consequence of the very great extension of the works, and other dynamos of a much larger capacity have been ordered.

The Traffic of the Metropolis.—The state of the street and railway traffic in London is already causing wise men to consider further schemes for rapid transit to the immediate suburbs, and Mr. J. Stephens Jeans's paper on this subject before the Society of Arts was opportune. A number of interesting statistics were given as to the various services, and also as to the accidents that occur, the light butcher's cart being the worst offender in this respect. The electric railways already progressing or proposed were mentioned. Mr. Jeans suggested the organised establishment of further quick-running cars, buses, or even overhead railways, to certain terminal points in the suburbs, and suggested the society might offer prizes as to the best means of dealing with the evils of street traffic. In the discussion, Major Flood Page, alluding to the Southwark Subway, stated that he was in conversation with a member of the firm who were going to work the line by electricity, and learnt that they were well in advance of their work, and that they would deliver the machinery as soon as the subway itself was ready. Major Page pointed out that there was here to be a three-minute service, which would mean no less than 2,300 train-miles per day.

American Institute of Electrical Engineers.—At the annual meeting of the American Institute of Electrical Engineers, to be held at New York this month, some interesting papers on electrical subjects are promised. The following is given as the list of papers to be read by the authors: "Modern Views on the Nature of the Electric Current," with experiments, by Prof. H. A. Rowland, of Johns Hopkins University; "The Inherent Defects of Lead Storage Batteries," by Dr. Louis Duncan, of Johns Hopkins University; "Motor Regulation," by F. B. Crocker; "The Measurement of Telephonic Currents," by Prof. Chas. R. Cross, of the Massachusetts Institute of Technology; "The Relation Between the Initial and Average Efficiency of Incandescent Lamps," by W. H. Peirce; "Some Results with Storage Batteries in Train Lighting," by Alexander S. Brown, of the Pennsylvania Railroad; "Magnetism, and its Relation to Induced E.M.F. and Current," by Prof. Elihu Thomson; "The Efficiency of the Arc Lamp," by H. Nakano, with an introductory note by Prof. E. L. Nichols, of Cornell University; "The Personal Error in Photometry," by Prof. E. L. Nichols; and "The Spiral Coil Voltameter," by H. J. Ryan, of Cornell University.

Natural Electricity.—An extraordinary tale comes from Burmah. Mr. Ronald H. King, an electrician well known to the Burmese, while on a prospecting and shooting expedition in the island of Labuan, is said to have discovered a mineral from which electricity can be obtained without apparatus of any kind whatever. The mineral is described as being in the form of a black stone, of excessive hardness, and very great specific gravity, being nearly as heavy as platinum. A small block in the shape of an irregular cube, measuring 4·3in. one way by 5·2in. the other way, was brought away, and, on bringing it into the testing-room, a strong effect was noticed upon the galvanometer. At first it was thought that the mineral was an ordinary lodestone, but on tests being made, it was found that the force was more akin to that of an electromagnet, and that a strong current would flow when the mineral was connected in a circuit. Further tests revealed that a difference of potential of 47 volts could be detected at the extremities, the internal resistance of the mass being 20 ohms. The block appears to waste away very slightly, leaving a slight grey powder upon the surface when connected up for some time. The electrician now uses the block to light a couple of incandescent lamps in his laboratory! We should like to see it.

Cardew's Safety Device for Transformers.—One of the great dangers with alternating currents is that the primary current may by some accident get into the secondary circuits by defective insulation in the transformers. Captain Cardew has devised an ingenious instrument, which is being made by Messrs. Drake and Gorham, to obviate this defect, and cut out the whole circuits if such an accident were to happen. The first instrument of the kind, which we were shown the other day, is to be exhibited at the Old Students' conversazione at Finsbury. It consists essentially of a very thin piece of aluminium foil, in the shape of two discs joined by a strip, lying loosely between two metal plates insulated from each other. These plates are connected respectively to the secondary circuit and to earth. If such an accident as that mentioned took place, the thin disc is attracted by electrostatic action due to the high potential of the primary, and touches the top plate, immediately connecting it to earth through the bottom plate. The slight leak to earth of the primary causes a fine fuse to go, and this short-circuits for a moment the primary, which, of course, causes both fuses to go and cuts out the transformer and the whole installation at the main fuse. Mr. Ferranti has, we believe, tried them on the Grosvenor circuit, and has ordered two dozen for fitting to installations.

Land Cable Telegraphs in Germany.—In Germany the telegraph lines are to very large extent laid underground in a cable network, communicating by one way or another to all parts of the empire. The saving in repairs and loss from the spring and autumn storms has been so great that more than one cable line has already paid for itself. Apart from the loss by breakage, it was often days before communication could be obtained, and the receipts of the telegraph department were seriously affected. At present, even if a storm caused damage to the telegraph posts in different parts of Germany, telegraph messages can still be forwarded by the cable lines. There are still occasional interruptions, but no telegrams have now to be refused, and the saving is stated at many hundred thousand marks yearly, and the working is more regular than the overhead lines by reason of the freedom from accidental disturbances. The cable stations in Germany are at Strasburg, Metz, Cologne, Emden, Bremen, Hamburg, Kiel, Stettin, Dantzic, Königsberg, Thorn, Posen, and Ratibor. There are no cable lines in South Germany, owing to the mountainous nature of the country. The cables cross Germany in all directions, so that in difficult cases, in the most roundabout way, any place of importance in Germany may be reached. The importance of these land cable lines in time of war is exceptionally great. Communication in the late war was liable to interruption during storms; but now the army authorities are relieved from anxiety on that head.

Zinc Recovery.—Our old friend, "recovery of products," has turned up again, this time in the shape of The General Zinc Recovery and Lighting Company, Limited,

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with offices in Deansgate, Manchester. We all know the phrases employed—new process, engine power prohibitive, no trouble and annoyance, primary battery, charged once a fortnight, etc. The new process consists in reconverting the exhausted solution by "a process only lately discovered," several thousand gallons to be treated at once, and the zinc recovered in a higher state of purity and used over and over again, or sold as chemically pure zinc. If it is a zinc-producing company, why not go to the zinc merchants and demonstrate the usefulness to them and try and get them to invest. But that is hardly the way to obtain money, and so electric light for nothing is the bait held out. We would not say it is impossible to recover the zinc, for of course it is possible; but the recovery requires power—probably engine-power with a dynamo, and if so, why not employ it for lighting, instead of all this paraphernalia of primary batteries, acid, accumulators, and carting backwards and forwards. Even without a mechanical process for recovery, the trouble with batteries for private consumers prohibits their use for the heavy currents required for lighting. To a technical mind the idea is absurd on the face of it, unless the promoters have something very different to say than we should expect they have. We presume they require money—from the public. They generally do. If so, we invite them to lay before us—as better able technically to judge in such matters than Manchester investors—any details which can possibly show there is any value whatsoever, as an investment, in a process for producing electric light and recovering the zinc.

The Weston Armature Patent.—American patents have a peculiar way of laying *perdu* for some years, and then coming out with a rush, and, like some savage beast, proceeding incontinently to devour all who may lay in their power. The Weston patent for sectional armatures s of this description, and although we hear little about it as affecting English dynamo manufacturers, it appears as if it were going to be a very formidable apparition to most American ones. It seems that both Edison and Edward Weston filed in 1882, the former a month the earlier, a patent claiming an armature made of iron plates separated by interposed insulating material, and mounted on an insulated shaft, Weston also claiming broadly the armature of iron plates with interposed insulating material, without reference to the shaft or to the type of armature. By some oversight, Edison's patent was allowed to issue prematurely in 1882, but an interference injunction was allowed, and priority of invention has finally been accorded to Weston. Meanwhile, the Weston patents have been secured by the Westinghouse Company through the recent arrangement with the United States Company, the original owners. The Weston patent has at last been issued, and is apparently broad enough to cover not only dynamo and motor armatures, but transformers as well. As it is the common custom of almost all manufacturers to construct their machines in this manner, it can be realised what an effect such a monopoly will involve. The Edison Company are "timely wise," and have already arranged for a royalty. To decide upon general issues, the Westinghouse Company have commenced a trial case in the courts, and have selected the Manhattan Electric Light Company, of New York, who use the Fort Wayne, or Slattery system, as defendants. The position of the general makers outside the pale of the wily Westinghouse, unless they can efficiently alter their methods of construction or can arrange to pay a royalty, is therefore inclined to become precarious. It will be interesting to learn what they have to say to prevent the threatened ravage into the domain of what has hitherto been regarded as public property.

Submarine Telegraphs.—In Committee of Supply, on a supplementary vote of £67,163 for the purchase of the Submarine Telegraph Company's lines, before the House of Commons on Wednesday, Mr. Raikes explained the terms arranged with the French Government for a through foreign traffic, and expressed his belief that the new system, long urged by the commercial community, would prove beneficial to this country alike from an international, postal, and financial point of view. It would largely increase facilities for commerce, and would, in all probability, give the country a profit of £15,000 or £20,000 a year. After some remarks from Sir G. Campbell, who unfavourably criticised the arrangement, Mr. Henniker Heaton contended that far too large a sum had been paid to the Submarine Company for their cables and other property, and he moved a reduction of the vote as a protest against what he regarded as an extravagant and unbusinesslike arrangement. Mr. Shaw-Lefevre also commented unfavourably on some of the items of the vote, and strongly urged that efforts should be made to reduce still further the cost of foreign telegrams; and Mr. Labouchere, contending that the Submarine Company had made an exceptionally good bargain, especially complained of the item for bonuses to be paid to employés of the company not taken over by the Post Office, which he insisted ought not to fall on the country. Sir J. Goldsmid, however, defended the arrangement as just, both to the country and to the company; and ultimately the reduction was negatived by 221 to 128, and the vote agreed to. The *Times* in commenting upon this arrangement says: "It seems to be the inveterate practice of the Post Office to spring matters of this kind upon the House of Commons and the country with as little notice as possible, and with as little explanation as is compatible with the not too lofty standard of Parliamentary candour. Mr. Henniker Heaton complained, not without reason, that notice of the vote had only been given yesterday morning, and the Postmaster-General's explanations, adroit, ingenious, and courageous as they were, certainly did not meet the objections of his critics, though they sufficed to secure a majority for the vote. The convention whereby the tariff for telegraphic messages between England and France is fixed for the next ten years at 20 centimes a word, has now been concluded, and the House of Commons has sanctioned it, probably feeling that in the circumstances it had no choice. It secures a certain advantage in comparison with the former tariff, but we cannot pretend to think that it has been framed with sufficient regard to the public convenience, or with adequate economy of the public funds. It is a bad bargain and an extravagant bargain. Not only have we paid a price fixed, as the Postmaster-General acknowledged, 'by competent and experienced valuers' to the Submarine Telegraph Company for their property, but we have added 10 per cent. to that price as a *solatium* for the extinction of a monopoly which, as the Postmaster-General also acknowledged, they were not compelled to sell to the Government, and could not have sold to anyone else. In addition to this, we have paid £5,500 nominally to clerks of the company deprived of their employment, but really to the shareholders of the company, who could not, any more than the Government, have allowed their clerks to be turned adrift without some provision for them."

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ELECTROLYSIS OF NICKEL SALTS.

BY ALEXANDER WATT.

The behaviour of solutions of metallic salts, under the influence of the electric current, appears to vary somewhat with different manipulators, examples of which I have before had occasion to direct attention to in former papers. In carrying out a series of experiments in the electrolysis of nickel salts, I have frequently found that the results were widely different from those obtained by other observers, and the only way in which I can account for such divergences—which in some instances were of a remarkably opposite character—is that the density ot the current employed and the metallic strength of the electrolyte must have been greatly different in each case. As an illustration of the differences referred to, I may mention that the late Alfred Smee, in his "Elements of Electro-Metallurgy," states that a solution of acetate of nickel yields a "black, powdery deposit, and is a bad one for obtaining reguline metal." Now, in my own experiments, I find that this salt, under the conditions stated further on, yields a good reguline deposit of a fairly good colour, and much softer than is usual with electrolytic nickel. In endeavouring to account for this wide difference between the results obtained by the gifted author of the work referred to and those which I have lately obtained, I venture to suggest that in Smee's experiments a far more powerful current must have been employed than was necessary for the reduction of metallic nickel from its acetate solution. Again, Merrick, employing the current from two Grove cells for the electrolysis of an acetate of nickel solution, obtained a good deal of the deposit in the form of black oxide, with a layer of reguline metal beneath. Now, with the current from two small Daniells —a battery of far lower E.M.F. than the Grove—I readily obtained a good reguline deposit of nickel from a solution of the same salt, and no trace whatever of black oxide. In pursuing electrolytic experiments with metallic solutions, I invariably make it a rule to commence with a low current and to increase the density as occasion may require, bearing in mind Douglass Jerrold's axiom, "hit a crown, but aim low." The density of the solution is the next consideration, and this is always modified, by dilution with water, until the most favourable condition is obtained for depositing reguline metal—the only useful aim in experiments of this nature. By adopting this method of procedure I have frequently obtained satisfactory results, even with solutions bearing a very bad character so far as their electrolytic behaviour is concerned.

The experiments which I am about to describe were conducted with the current from one or more small Daniell cells, according to the conductivity of the electrolyte, the anode being a plate of rolled nickel, furnished by Messrs. H. Wiggin and Co., of Birmingham, to whose courtesy, also, I am indebted for some excellent commercial salts of nickel, with which many of my experiments were conducted. The cathodes employed consisted of a series of brass plates 1in. wide by 3in. long, to each of which was soldered a copper wire. The current density ranged from ·715 to 1·131 amperes, the latter being the current from three cells arranged in series. In each case the current from a single cell was first tried, with nearly equal electrode surface, and a second, or third, cell connected whenever the current was found to be insufficient for obtaining a prompt coating of nickel on the receiving plate. It should be mentioned that in nickel-plating generally it is always advisable to employ a current strong enough to ensure a coating of the cathode almost immediately after immersion, or, as the Americans term it, to *strike* the deposit at once. When nickel deposition takes place slowly, and the object does not become coated with the metal almost instantly after immersion, it is a sure sign, all other things being equal, that the current is too weak. In ordinary nickel-plating, it is customary to employ a much larger surface of anode than that of the cathode or articles to be coated, which, even when the current is obtained from a dynamo-electric machine, appears to be absolutely necessary with solutions of the double sulphates of nickel and ammonia. When voltaic batteries have been employed, a still larger anode surface has generally been found necessary; but in the experiments which I have lately followed up I have endeavoured, whenever practicable, so to accommodate the current to the solution, or *vice versâ*, that a nearly equal surface of the electrodes would enable me to obtain a prompt "striking" of the film within a few seconds after immersion of the cathode. These I consider to be the proper conditions of working, and if they can be carried out in practice will involve less cost for nickel anodes—an object of importance when heavy cast anodes are employed, as I have often known to be the case.

1. *Acetate of Nickel.*—A solution was prepared by digesting recently-precipitated and moist carbonate of nickel in commercial acetic acid containing 15 per cent. real acid until a neutral solution of a rich green colour was obtained, which contained about four troy ounces of the dried salt per quart of solution, or, say, 16 ounces to the gallon. The current from a single cell was first tried, but the cathode, a clean brass plate, received no deposit of metal; a second cell was then connected in series, when a film of nickel soon formed upon the plate, which, although of a rather dark colour, was perfectly uniform and of a good reguline character. After about an hour's immersion, the plate was removed, rinsed and dried, and a steel burnisher applied, which readily brightened the surface, showing that the deposited metal was softer than the metal obtained from the ordinary double sulphate solutions. In this experiment, the anode surface immersed in solution was about *one-third less* than that of the cathode, and the deposit took place on both sides of the latter, which is not always the case with nickel solutions. The current which effected the deposit from this solution was about 1·012 ampere, the total surface of the cathode being six square inches.

2. *Acetate of Nickel by Electrolysis.*—It was next determined to ascertain whether the nickel anode would freely dissolve by electrolytic action in a solution of acetic acid, for which purpose one volume of commercial acetic acid was added to two volumes of water, and this was electrolysed with the current from three small Daniells in series. Under these conditions, a brass plate, used as the negative electrode, received a coating of nickel in rather less than an hour, the solution having acquired a slightly green tinge. It was next resolved to see if a stronger solution of the acid would be more prompt in its action, and for this purpose the undiluted commercial acid was tried, with three cells as before, when in about a quarter of an hour a brass plate became coated with a bright but wavy deposit of nickel of a good white colour.

3. *Acetates of Nickel and Ammonia.*—A solution was next prepared by adding to a strong solution of nickel acetate one of acetate of ammonia, and the bath thus prepared was electrolysed, as before, with the current from two cells, when a deposit of a good white colour was obtained upon a brass plate. During the electrolysis of this solution there was a good deal of gas given off at the anode, but very little at the negative electrode, where, however, minute bubbles of hydrogen were noticed to form slowly and to rest on the plate with great tenacity. In about 15 minutes a dense white foam surrounded the anode, caused by the evolution of minute bubbles of gas at that electrode.

4. *Acetates of Nickel and Chloride of Sodium.*—To a strong solution of acetate of nickel was added one of chloride of sodium, and the mixture was electrolysed with the current from two cells, which, however, proved to be too weak, so a third cell was connected, when a film of nickel soon formed upon a clean brass plate, which was of a very good white colour. When the third cell was introduced the deposition took place somewhat too speedily, therefore a portion of the anode was withdrawn from the solution, leaving the immersed surface of this electrode somewhat less than that of the negative plate.

5. *Acetates of Nickel and Potassium.*—A bath was prepared by adding to a strong neutral solution of acetate of nickel a solution of acetate of potassa. With this bath, which appeared to be a somewhat better conductor than the preceding, the current from two cells only was found sufficient to obtain a deposit of nickel on a brass plate, which occurred soon after it was immersed in the liquid. In this case there was only a moderate evolution of gas at the positive electrode, while there was none at all at the negative.

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The deposited metal from this electrolyte was very uniform and white, and the surfaces of the electrodes were about equal. A bath of this composition might be useful for coating metals with nickel.

6. *Citrate of Nickel.*—A solution was prepared by digesting recently-precipitated and moist carbonate of nickel in a strong and hot solution of citric acid, in which it became freely dissolved, forming a green solution. The bath thus formed was first tried with the current from one cell, but as no deposit of metal took place a second cell was connected, when a film of nickel somewhat slowly formed upon a brass plate—the electrodes being of about equal surface. The colour not being white enough, a larger surface of anode was immersed, when the colour improved. It was noticed, however, that the metal deposited but slightly on the back of the plate. A better result was afterwards obtained by taking the current from three cells in series and reducing the anode surface.

7. *Nickel Carbonate in Sulphate of Ammonia.*—A solution was formed by adding moist carbonate of nickel to a strong and hot solution of sulphate of ammonia, in which the carbonate freely dissolved, forming a bluish-coloured solution. With the current from one cell no deposit was obtained from this bath, but when a second cell was connected deposition took place promptly ; the film, however, was not of a very good colour. There was very slight evolution of hydrogen at the cathode, and the deposit took place on both sides of the plate.

8. *Nickel Carbonate in Bitartrate of Potassa.*—A hot solution of the bitartrate (cream of tartar) was first prepared, to which was added, a little at a time, moist carbonate of nickel, each portion being allowed to dissolve before the next was added, until the solution became nearly saturated. From one to three cells were tried consecutively, but little or no metal was deposited upon the cathode, which, however, became coated with a copious gelatinous layer of a brown colour, doubtless hydrated oxide of nickel. This deposit occurred on both sides of the plate.

9. *Nickel Carbonate in Chloride of Ammonium.*—A hot solution of salammoniac, was first prepared, to which was added, gradually, as before, moist carbonate of nickel and the resulting solution, which was of a green colour, was then allowed to cool. With the current from the cell, a tolerably prompt deposit of nickel was received upon a brass plate, the colour of which, however, was of a yellowish tint. A second cell was then introduced, when the colour of the film greatly improved, and soon became of a good white colour. No hydrogen was liberated at the negative electrode, and the deposit occurred on both sides of the plate.

10. *Nickel Carbonate in Sulphate of Alumina.*—A solution was prepared by digesting moist carbonate of nickel in a hot solution of sulphate of alumina, in which the nickel salt became freely dissolved, forming a green solution. The current from one and two cells respectively was first tried ; but since no metal became deposited, a third cell was put in series, when it was found that a black granular deposit formed on the cathode, while a deep black coating also appeared on the back of the plate. After a few minutes a copious green crystalline deposit formed on the cathode, and fell off its surface to the bottom of the vessel—probably a basic salt of nickel.

11. *Nickel Tartrate.*—A solution of this salt was prepared by digesting moist carbonate of nickel in a strong and hot solution of tartaric acid until a nearly neutral solution, which was of a pale green colour, was obtained. With this solution, which was a poor conductor, no deposit of nickel could be obtained until three cells had been arranged in series, when a film of nickel of an indifferent colour slowly formed on a brass plate. It was noticed that the cathode became more fully coated with metal on the back than on the front—a peculiarity which I have observed, and recorded in some former papers in this journal on the "Peculiarities of Electro-Deposition."

12. *Lactate of Nickel.*—A solution of this salt was prepared by digesting moist carbonate of nickel in lactic acid, in which the nickel salt became readily dissolved, forming a green solution, which was afterwards diluted with water. The diluted solution failed to yield a deposit with the current from a single cell, and only a slight film was obtained with two cells ; with three cells, however, a brass plate became coated with nickel of fairly good colour soon after immersion. Beyond the fact that this weak acid readily dissolved the nickel carbonate, there was nothing of interest in the electrolysis of the resulting liquid.

13. *Phosphate of Nickel in Bisulphate of Potassa.*—A quantity of phosphate of nickel was first prepared by adding a solution of common phosphate of soda to a solution of nickel sulphate, and the resulting pale green precipitate was afterwards well washed with water. A strong solution of bisulphate of potassa (*sal enixum*) was next made, to which a portion of the moist precipitate of nickel phosphate was gradually added until the liquid became saturated, when a nearly colourless solution resulted. This was electrolysed with the current from three cells, but only a slight film of nickel was obtained—chiefly on the back of the plate. There was a vigorous evolution of gas at both electrodes.

14. *Nickel Phosphate in Cyanide of Potassium.*—A solution was prepared by digesting recently precipitated phosphate of nickel in a moderately strong solution of cyanide of potassium, the resulting liquid having a slightly brown tinge. With the current from three cells, no metallic deposit was obtained, but a red salt formed at the cathode, which diffused itself through the liquid ; a deposit of a black colour appearing on the surfaces of the anode. There was a copious evolution of gas at both electrodes.

(To be continued.)

CORRESPONDENCE.

FIREDAMP DETECTORS.

To the Editor of The Electrical Engineer.

Sir,—I should like to point out that Mr. Niblett is in error in supposing that the wire gauze used in the Davy lamp renders it safe in an explosive mixture of gas under all circumstances. In fact, under the modern conditions of ventilation, where very powerful ventilating currents are used, it is doubtful if any of the oil lamps now in general use are absolutely safe, or even practically safe under certain conditions, such, for instance, as the sudden emission of a blower of gas. In fact, one of the principal reasons why mining engineers are so ready to take up electric safety lamps is because there is absolutely no contact between the surrounding atmosphere and the glowing filament. And the only doubt which has so far been thrown on its safety has been the apparent uncertainty whether heat will remain long enough in the filament, in case of breakage, to ignite gas, if any be present.

Immediately you bring the gas into contact with a glowing metal, of whatever form, no matter that gauze may be present, you destroy this absolute safety.

Another point that I should like to mention is the detector that is required to take the place of the Davy lamp should equal it in simplicity, and should be capable of being placed in the hands of every practical working collier, and it should denote quickly and unmistakeably the presence of gas—not necessarily its percentage. The collier requires a guide to tell him when he is in a gaseous atmosphere for two reasons :

First, for the safety of the mine.

Secondly, for the sake of his own health, so that he may not be breathing a dangerous atmosphere without knowing it.

For the officials of the colliery an instrument showing in a simple and reliable manner the percentage of gas present will be of great service, but to the working collier such an apparatus would be useless.—Yours, etc.,

Sydney F. Walker.

P.S.—I trust the above remarks will be taken in the spirit in which they are given—viz., to help Messrs. Pitkin and Niblett in the work they have in hand.

MEDICAL BATTERY COMPANY, LIMITED.

To the Editor of the Electrical Engineer.

Sir,—My attention has been drawn to last week's *Electrical Engineer* containing particulars regarding the regis-

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tration of "The Medical Battery Company, Limited." To prevent any misunderstanding, therefore, I shall feel obliged if you will kindly inform your readers that, in order to make further important advancements in the practice of medical electricity, and to obtain power to carry out Mr. Harness's idea of establishing a Free Electropathic Hospital, it was found necessary to alter our memorandum and articles of association. To meet the requirements of the Joint Stock Companies Acts, the directors have had to conform to the legal formality of re-registering the company. Mr. C. B. Harness has been appointed president of the company, and the title, capital, directors, and shareholders remain exactly the same as before.

It is intended to still further extend the spacious premises of the company, so as to meet every possible requirement for the perfect treatment of disease by electricity.—Yours, etc., CHAS. R. SHARMAN, Secretary.

London, W., May 20, 1889.

ON LIGHTNING, LIGHTNING CONDUCTORS, AND LIGHTNING PROTECTORS.*

BY DR. OLIVER LODGE, F.R.S., MEMBER.

(*Concluded from page 399.*)

Injury to Gas and Water Pipes by Lightning.†

The city gas company of Berlin, having expressed the fear that gaspipes may be injured by lightning passing down a rod that is connected with the pipes, Prof. Kirchhoff has published the following reply: "As the erection of lightning-rods is older than the system of gas and water pipes as they now exist in nearly all large cities, we find scarcely anything in early literature in regard to connecting the earth ends of lightning-rods with these metallic pipes, and in modern times most manufacturers of lightning-rods, when putting them up, pay no attention to pipes in or near the building that is to be protected." Kirchhoff is of the opinion, supported by the views of a series of professional authorities, that the frequent recent cases of injury from lightning to buildings that had been protected for years by their rods, are due to a neglect of these large masses of metal. The Nicolai Church in Griefswald has been frequently struck by lightning, but was protected from injury by its rods. In 1876, however, lightning struck the tower and set it on fire. A few weeks before, the church had had gaspipes put in it. No one seems to have thought that the new masses of metal which had been brought into the church could have any effect on the course of the lightning, otherwise the lightning-rods would have been connected with the gaspipes, or the earth connection been prolonged to proximity with the pipe. A similar circumstance occurred in the Nicolai Church in Stralsund. The lightning destroyed the rod in many places, although it received several strokes in 1856, and conducted them safely to the earth. Here, too, the cause of injury was in the neglect of the gaspipes, which were first laid in the neighbourhood of the church in 1856, shortly before the lightning struck it. The injury done to the schoolhouse in Elmshorn, in 1876, and to the St. Lawrence Church, at Itzehoe, in 1877, both buildings being provided with rods, could have been avoided if the rods had been connected with the adjacent gaspipes.

"If it were possible," says Kirchhoff, "to make the earth connection so large that the resistance which the electric current meets with when it leaves the metallic conducting surface of the rod to enter the moist earth, or earth water, would be zero, and it would be unnecessary to connect the rods with the gas and water pipes. We are not able, even at immense expense, to make the earth connections so large as to compete with the conducting power of metallic gas and water pipes, the total length of which is frequently many miles, and the surface in contact with the moist earth is thousands of square miles. Hence the electric current prefers for its discharge the extensive net of the system of pipes to that of the earth connection of the rods, and this alone is the cause of the lightning leaving its own conductor."

[This, like many another theoretical remark, is not to be supposed true.—O. J. L.]

Regarding the fear that gas and water pipes could be injured, he further says: "I know of no case where lightning has destroyed a gas or water pipe which was connected with the lightning-rod; but I do know cases already in which the pipes were destroyed by lightning because they were not connected with it. In May, 1809, lightning struck the rod on Count von Seefeld's castle, and sprang from it to a small water-pipe, which was about 80 metres from the end of the rod, and burst it. Another case happened in Basel, July 9, 1849. In a violent shower one stroke of lightning followed the rod on a house down into the earth, then jumped from it to a city water-pipe, a metre distant, made of cast iron. It destroyed several lengths of pipe, which were packed at the joints with pitch and hemp. A third case, which was related to me by Prof. Helmholtz, occurred last year in Gratz. Then, too, the lightning left the rod and sprang over to the city gaspipes, even a gas explosion is said to have resulted. In all three cases the rods were not connected with the pipes. If they had been connected, the mechanical effect of lightning on the metallic pipes would have been null in the first and third cases, and in the second the damage would have been slight. If the water-pipes in Basel had been joined with lead instead of pitch, no mechanical effect could have been produced. The mechanical effect of an electrical discharge is greatest where the electric fluid springs from one body to another. The wider this jump the more powerful is the mechanical effect. The electrical discharge of a thunder-cloud upon the point of a lightning-rod may melt or bend it, while the rod itself remains uninjured. If the conductor, however, is insufficient to receive and carry off the charge of electricity, it will leap from the conductor to another body. Where the lightning leaves the conductor, its mechanical effect is again exerted, so that the rod is torn, melted, or bent. So, too, is that spot of the body on which it leaps. In the examples above given, it was a lead pipe in the first place, a gaspipe in the last place, to which the lightning leaped when it left the rod, and which were destroyed. Such injuries to water and gas pipes near lightning-rods must certainly be quite frequent. It would be desirable to bring them to light, so as to obtain proof that it is more advantageous, both for the rods and the building which it protects, as well as for the gas and water pipes, to have both intimately connected. Finally, I would mention two cases of lightning striking rods closely united with the gas and water pipes. The first happened in Düsseldorf, July 23, 1878, on the new Art Academy; the other August 19, last year, at Steglitz. In both cases the lightning-rod, the buildings, and the pipes were uninjured."—*Deutchen Bauzeitung.*

48. That lightning sometimes does things which is, on the hitherto available views, inexplicable, is evidenced by the following record by one who, of all others, made lightning-conductors his hobby, who acquired an immense amount of experience concerning them, and to whom the carrying out of probably the most perfect system of protection in actual use is largely due—I mean the late M. Melsens:

Note on the Lightning Flash at Antwerp Railway Station, July 10th, 1865. By M. Melsens.

"I have described this lightning stroke, which was very harmless, since all the damage was confined to the breaking of a square of glass in the roof of the covered station of the railway at Antwerp; but, in connection with it, I found myself confronted by so extraordinary a phenomenon that I had to search through all the descriptions of lightning strokes which might offer a certain analogy to this with which I have to do. It was only on looking through my notes again, and returning several times to the place, that I have ventured to describe this very extraordinary stroke, and I have only published it after a long time, when it seemed to me that I could establish it upon careful observations and experiments which seemed of a nature to corroborate my conclusions."

Mention made of nineteen lightning flashes, which present some analogy to that which struck Antwerp Station: "A few words are sufficient to show the peculiarity of the phenomenon. The lightning crossed a square of glass and produced in it a hole similar to that which would be produced by a projectile thrown upwards from below at a slow rate, say, from 30 to 50 metres per second, and travelling from earth towards the sky. The edges of the hole were melted. I have given a description of the experiments I made, together with Ruhmkorff, to prove that in reality lightning does travel from the earth towards the sky. The proof which I give of it seems to me decisive.

"The extraordinary fact, as I have remarked, is to see the lightning pass, by means of a very bad conductor, through a square of glass 4 millimetres in thickness, forming a parallelogram of 0m. 35 × 0m. 38, having angles of 83deg. and 97deg.

"The opening produced was at a distance of some centimetres from iron and lead conductors, which were in perfect metallic communication with all the iron of the station. The weight of this latter exceeds 120 tons. But the anomaly does not stop there. To the right and left of the glass roof in which the broken pane was, the covered platform of the station has a roof of zinc No. 13, presenting to the lightning a surface of 3,000 square yards. The weight of this zinc is not less than 15 tons. The three tall rods of the lightning-conductor are in immediate metallic contact with this zinc and with the conductor, and the whole is connected to 28 hollow columns, serving to carry off rainwater. The collection of these metals would allow one to suppose that they were well adapted to carry off lightning or any such disturbance easily; but in this instance it despised them, and chose a path entirely unexpected. Let me add that there was a shed some 62 metres from the station

* Paper read before the Institution of Electrical Engineers.

† See also on this subject two abstracts in *J. I. E. E.*, No. 77, vol. 18, 1889, of papers by Profs. W. Kohlrauch and A. Vollez, respectively.

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built on hollow columns and iron framework, and the greater part of it roofed with zinc; moreover, about 40 metres on the opposite side were more sheds roofed with zinc ; the metallic surface was not less than 2,000 square metres. Moreover, in my investigation, I might mention plenty of other metals in communication more or less perfect with the earth, grids, sconces, gaspipes, telegraph wires, rails, etc. Besides, the whole of the platform may be considered as one large lightning conductor in perfect communication with a very damp earth, and offering hardly any resistance to the passage of the current from the building."

49. Of all the buildings in the world not wholly made of metal, the Hôtel de Ville at Brussels was and is the most perfectly and elaborately protected. No electrician exists but would a year ago have asserted, had they gone over it, that it was absurdly and exaggeratedly safe from damage by lightning. Last July it was struck and set on fire.

The case has been investigated and published in the *Bulletin de la Société Belge d'Electriciens*, for September and October, 1888.

It seems to have been owing to secondary or induced electric surgings in a horizontal bar of metal totally disconnected from anything ; not pretending to lead toward earth, and being some little distance below a stretch of lightning-conductor not offering itself as an object to be struck. On all the old views it was utterly insignificant. However, as a matter of fact, although not struck, although it did not probably even receive a side flash, yet the induced surgings set up in it, induced by Maxwell and Heaviside's electromagnetic waves, were so violent as to ignite some gas and cause a small fire. Had it been connected to the conductor, the sparking from it would probably have been stronger.

This occurrence, and certain sparkings in the wall paper of the Royal Institution (*Nature*, March, 1889), the sparkings, too, in the gilding of the present hall, are plain and straightforward intimations that the old views on the subject of electric conduction are hopelessly, and absurdly, and dangerously inadequate. It is time that the prophets of that old superstition were slaughtered by the brook Kedron.

Practical Questions.

50. There remains to consider what is to be the practical outcome of all this. What improvements in the erection and testing of lightning-conductors are possible. This is a matter well worthy of discussion, and eminently suited to it. It is a matter on which I have not the slightest wish to be dogmatic ; and if I make a few apparently definite assertions, it is only by way of expressing such judgment as I have been able to form at present, and they are to be taken as intended more by way of suggestion and question than anything else.

With this proviso I should be disposed to make some such statements as the following :

51. All parts of a lightning-conductor, from points to roots, should be of one and the same metal, to avoid voltaic action.

52. Joints should be avoided when possible, and should be made substantially when necessary. Allowance for expansion and contraction must not be forgotten.

53. Sharp bends, and corners, and curves, and roundabout paths to earth should be avoided as far as possible.

54. The use of copper for lightning-conductors is a needless extravagance.

55. Iron has advantages over every other metal.

56. The shape of cross-section is but little matter. Flat ribbon has a slight advantage over round rod, but not enough to override questions of convenience.

57. Liability to be deflagrated by a powerful flash determines the minimum allowance for size of cross-section. No consideration of conductivity and greater ease of path has the least weight in this connection.

58. It is hopeless to pretend to be able to make the lightning-conductor so much the easiest path that all others are protected. All possible paths will share the discharge between them, and a lot of apparently impossible ones.

59. A good and deep earth should in general be provided, independent of water and gas mains.

60. If the conductor at any part of its course goes near water or gas mains it is best to connect it to them.

61. If the place to be protected has water or gas pipes inside it, the conductor should be connected to their mains underground.

62. At all places where water and gas pipes come near each other, and, in general, wherever one metal ramification approaches another, it is best to connect them metallically.

63. The neighbourhood of small-bore fusible gaspipes and indoor gaspipes in general should be avoided in erecting a lightning-conductor.

64. Into powder magazines and such like places no gas or water pipes should be permitted to enter, unless the whole building is made of metal, and they are elaborately connected to it at the point where they enter.

65. It is not wise to erect very tall pointed rods above the roof of a building.

66. A number of points all along the ridge of a roof is better than only a few.

67. Any part of a building is liable to be struck, and, to make quite secure, every prominent part of the outside should have a rod running along it.

68. Earth-connected as well as insulated bodies are liable to spit off sparks.

69. No complete security can be attained unless the whole building be metal-lined, floor and all.

70. In ordinary houses it may be well to try and insulate the lightning-conductor from the walls so as to lessen the chance of side flash to metal stoves and things inside.

71. In chimneys it may be well to use insulators to protect the bricks from concussion.

72. The cheapest way of protecting an ordinary house is to run common galvanised iron telegraph wire up all the corners along all the ridges and eaves, and over all the chimneys, taking them down to the earth in several places, and at each place burying a load of coke. Rain-water spouts and other outside metal, if all well connected together, may likewise be utilised.

73. Connecting a lead roof or other such expanse with a lightning-conductor is not an unmixed good, for it virtually increases the dangerous proximity of the lightning-conductor, and may inadvertently bring it near to many objects which else might have escaped.

74. One of the most difficult things is to know what to connect and what to avoid.

75. The orthodox rule, "Connect all pieces of metal to the lightning-conductor," requires modifications, thus : connect all pieces of metal to each other and to the earth, but not to the lightning-conductor.

76. It may be always reckoned safe to earth things independently. It is often not safe to connect them to the lightning-conductor : *e.g.*, an inside lining of a chimney should be well earthed, but should not be used as lightning-conductor, nor connected with it. The same with rain-water pipes and gutters. The same, also, probably, with lead roofs.

77. In connecting pieces of metal to each other, if they happen to form a nearly closed circuit, the circuit should be metallically completed.

78. Over the top of tall chimneys it is well to take a loop or arch of the lightning-conductor, made of any stout and durable metal.

79. Lightning-conductors should be always outside and easily visible.

80. A conductor detached from the building to be protected is safer than one in close contact with it.

81. For powder magazines and such like an outer cage surrounding the building, with sky points and earth roots, and an inner case on the building, with independent earth terminals only, is the safest plan.

82. If under these circumstances there be no gaspipes nor much ramifying metal work inside the building, and no metal at all going near either cage, the interior may be considered perfectly safe.

83. The inner cage may often be conveniently made of continuous sheet-iron. The outer cage need not then be at all small-meshed ; in fact, it need be little more than a dozen vertical conductors.

84. The resistance of an earth may be tested in the customary way to guard against actual breaches of contact by rust or workmen ; but no overweening confidence must be felt, even though the resistance turn out the thousandth of an ohm or less.

85. A Wimshurst machine and couple of Leyden jars afford a convenient mode of testing a conductor for flagrant defects. The testing should be done in the dusk or in moonlight, so that there may be light enough to work by, and yet sparks be visible.

86. Telephones are the handiest things to detect electric surgings in conductors inside the house while discharges are being made to the conductor. But vacuum tubes, gas leaks, Abel's fuses, etc., can also be employed.

87. Another mode of testing can be carried out on an insulated rod, with an induction coil and spark gap after the manner of a great Hertz oscillator. This is probably the most searching plan. Sparks will then be probably obtained from all the gas-brackets, water-taps, and picture-rails in the house.

88. Telegraph stations, and houses supplied with electricity from overhead wires, should have an efficient lightning-protector at the place where the wires enter the house.

89. When a number of houses are wired up together for lighting, even by undergroun wires, it may be well to disconnect them by means of intervening lightning-protectors on the principle of fireproof doors.

90. A central lighting station, having a tall chimney connected to its boilers and dynamos, should be, by a lightning-protector, disconnected from the leads which carry the current from it ; because a small fraction of a stroke getting into the leads might destroy a number of lamps, especially if they were already working at something like their full power.

91. Telephone arrangements, and any long length of close-packed insulated wires (even underground) should be protected by lightning-protectors, else the insulation is apt to be sparked through and spoiled.

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IMPORTANT NOTICE.

Although the Paris Exhibition is open, the major portion of the exhibits are in so backward a state that any systematic description is almost impossible at present, so we shall wait a short time till the chaos of packing cases becomes a neat arrangement of exhibits. It is needless to tell our readers that—so far as our description of the electrical exhibits is concerned—our attention will, in the first place, be directed to the interests of English and American exhibitors. A special edition of this paper, with the report of the exhibition in two languages—English and French—will be obtainable in the Exhibition.

MAJOR MARINDIN'S REPORT.

Major Marindin must be congratulated upon having so soon issued his report upon electric lighting in London. In another column will be found the conclusions he has come to, together with a letter from the Board of Trade to the Chairman of the London County Council. The report strikes us as an admirable common-sense affair, overcoming the difficulties of the situation by accepting them and making the best possible face upon the matter. Broadly speaking, the report suggests that things should be left pretty generally as they are, and that companies who have obtained sites and arranged areas should retain those areas. Criticism upon this report must be somewhat unsatisfactory till the model provisional order, based upon it, is ready. This model order is promised by the Board of Trade as early as possible. It will be the order that will regulate the practical details of metropolitan work, and will tend to make electric lighting a success or a failure.

It will be well, however, to point out the salient features of Major Marindin's conclusions, which we are glad to see partake very much of the nature and character of those we have from time to time promulgated. In the first place, he thinks the local authorities should be consulted, and their opinions deferred to as much as possible, leaving the loophole that if these opinions are clearly obstructive and founded upon no good reasons they may be ignored. Our readers well know our contention all along has been that the local authorities must know better than any central body what their special district requires, and it is hardly within the bounds of practical local government that annually elected representatives will prove wilful obstructionists. If electric lighting is to progress, it will not be by running counter to local ideas ; and we trust that the Board of Trade will have no occasion to be brought into antagonism with any local body, because the latter objects on "general grounds."

The fixing of a maximum price and the revision of this price periodically is not so important as many may deem at first sight. The electric lighting industry is not without a competitor. From a business point of view there seems no possibility of its ever being left in the position of a monopoly, and therefore those engaged in the financial branches of the industry will be unable to impress what price they please. The charges will naturally be such as will enable good work to be done, and a fair return made for the capital expended. The lighting must increase against competition with gas, and for years prices will be somewhat regulated by such competition till, even if the whole City is electrically lighted, prices will have no chance of being raised. It will be seen that our opinion differs somewhat from that expressed in the report which says, "The competi-

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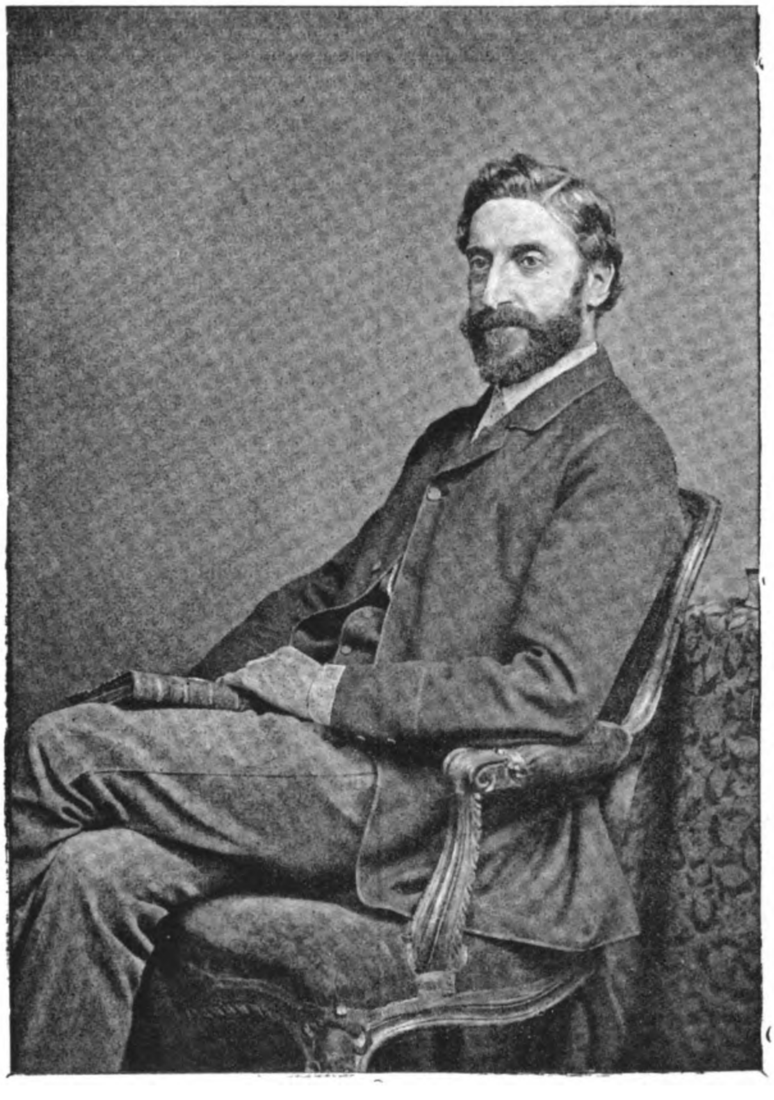
tion with gas, which at present at any rate, and probably for many years to come, will appeal to a totally different class of customer, will not be nearly so effective, while the potential competition from the power of calling in a new company in an area badly served is not likely to be called into play until the bad service has passed through many degrees, and has reached a very low ebb indeed."

When we first read the report we thought the phrase, "That in the abstract, competition is desirable," would be followed by one "That in the concrete it would be found impracticable," but, on the contrary, while the latter may be read between the lines it is not so definitely stated, and the weakest point in the report suggests that competition in the same area may be allowed when limited to two different systems. Would this conclusion have been different if Messrs. Ganz had been six weeks or six months earlier with their alternate current motor, for the reason given for this competition is that power cannot be distributed by alternate current systems. A previous paragraph militates against the weakness of this suggestion, in that where two companies possess powers over the same area "different streets should be scheduled for each." This seems to mean, while permitting competitors into the same area, nominally they are really to be kept in distinct sub-areas. The result, if permitted, will be costly, with no benefits accruing either to consumers or shareholders. We except the case as totally distinct where one company requires running powers only through the district of another company. At any rate, if the alternate current motor is commercially practicable, Major Marindin's reason falls to the ground, and likewise his conclusion, hence we may take it that the condition, one company, one area will prevail.

The period limiting the use of pioneer overhead wires is two years. This should meet the approval of the various companies interested. The remainder of the report deals with the distribution of areas among the existing companies. It is not within our province to discuss this distribution, the companies having fully presented their views, and no doubt each competitor has felt grateful on some points, and dissatisfied on others. This report, at any rate, will, for the time being, clear the air, and the various powers given will enable the companies to get to work. They have been waiting long enough. Once get to work without fear of legal tinkerings or alterations from the Board of Trade or any other authority, the real progress of electric lighting will depend upon the manner in which the work is carried out, and the arrangement of the details governed by the model order. The companies in the field, so far as we can gather, are determined to leave nothing undone to ensure success. May they obtain it, and London become, as it should be, the best lighted city in the world.



JOHN HOPKINSON, F.R.S., D.SC.

JOHN HOPKINSON, F.R.S.

Among the quartet of vice-presidents of the Institute of Electrical Engineers, not the least renowned is Dr. John Hopkinson. In the ordinary course of events we may expect Dr. Hopkinson to be our next president, if, as we assume, the election is by seniority. Few members of the Institute have contributed more scientifically accurate information to the world than Dr. Hopkinson. Like a few other men, he goes to the very root of the questions he takes up, and the results at which he arrives stand the test of the sharpest criticism. Dr. Hopkinson is a Lancashire

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man, born at Manchester in 1849, the eldest son of Mr. Alderman Hopkinson. His mother is a daughter of the late Mr. John Dewhurst, of Skipton. The rudiments of his education were obtained under Mr. C. Willmore, at Linden Grove School, and subsequently at Queenwood College. In his sixteenth year he went to Owens College, where he remained for two and a half years, and then went to Trinity College, Cambridge. In 1871 he was senior wrangler and Smith's prizeman. It is often said that few senior wranglers make their mark in the world, but we believe this statement is the result of ignorance. It would be easy to give name after name of those who, having achieved this distinction, and having cast aside the scholastic for the practical work of the world, have obtained a position at the head of the profession adopted. Dr. John Hopkinson is a proof of this so far as the electrical engineering profession is concerned, and we might cite the names of Moulton among lawyers, and Sprague among actuaries, in support of our contention.

While at Cambridge he graduated at London University, where he took the D.Sc. degree. Following the axiom that "all work and no play, etc.," he paid a moderate attention to athletics, rowing in the college eight, and as a ped., travelling the mile sufficiently well to win a race just before the tripos examination. In 1872 he joined Messrs. Chance and Co., near Birmingham, as their engineer. This firm stands prominent as producers of optical apparatus for lighthouses. Dr. Hopkinson resided in Birmingham about six years, and then removed to London. He has introduced many improvements into lighthouse apparatus, notably the group flashing apparatus, and has been uniformly successful in all his designs, which now probably exceed, so far as special signs are concerned, in number those of any other engineer. Upon his removal to London, besides his special work, he commenced general practice as an engineer, and has since then devoted very careful attention to electrical engineering. His work in connection with dynamos has been very important. In his paper before the Mechanical Engineers in 1879 he first introduced the methods of graphically depicting certain phenomena by means of characteristic curves. The use of these curves has become as common and as useful in dynamo work as indicator curves are in engine work. Early in 1883 he made improvements on the Edison machine, and in conjunction with his brother, Dr. Edward Hopkinson, these improved machines have been constructed by Messrs. Mather and Platt. Some exceptionally valuable work has been brought forward in lectures or papers read before the Institution of Civil Engineers, and the Institute of Electrical Engineers. Dr. Hopkinson was elected a member of the Royal Society in 1878.

SECONDARY BATTERIES.*

BY J. APPLETON.

(*Concluded from page 400*).

Unfortunately, however, as in other things, what is theoretically perfect in secondary batteries is often practically bad. It is obvious that a plate of this type cannot discharge at such a rapid rate as a Crompton-Howell or E.P.S. plate, and this is a great disadvantage, especially in the work that the secondary battery will have to do in the future. The internal resistance is also comparatively high, owing to the very small surface of contact. It is possible to make a solid peroxide plate so dense, and therefore mechanically strong, that its life will be comparatively long, but then the capacity is sacrificed, and, on the other hand, a plate of wonderful capacity can be made, but unfortunately it is very fragile, and dies early. Here is a piece which has shared this fate. Another great difficulty to be overcome with this type of plate is the contact. Platinum is expensive, and must be used sparingly, and it is by no means an easy job with an unlimited quantity of platinum to make a good and lasting contact. It is possible to obtain a few discharges without any difficulty, but sooner or later the contact becomes coated with a film which increases the resistance. I mention this type of plate, as I think in this direction endeavours will be made to produce a battery which has no local action and will not require to be overcharged to keep it in good condition.

I have here samples of a new material for making battery-box linings, a little description of which may be of interest to you. [Several linings shown] It is perfectly acid-proof, and can be worked up into any desired shape. By slightly heating it can be bent or moulded, and retains the shape when cold. The joints are not merely stuck together, but the surfaces are dissolved with a solvent, and under pressure they unite to form practically one solid piece. It is a splendid non-conductor, and is admirably suited for this work.

Another direction in which work has been done is to produce an accumulator with an alkaline solution and strong metal plates. This has been done, with great success apparently, by Messrs. Commelin and Desmazures, in France. They use a copper plate made of compressed copper opposed to a plate of iron-wire gauze in a solution of zincate of potassium. During the charge zinc is deposited on the iron gauze, and the oxygen absorbed by the copper plate. In the discharge the zinc is dissolved, combining with the oxygen from the copper plate. A very high discharge is obtained from these cells. A box containing three cells weighs 28lb., and gives a discharge of 150 ampere-hours at about 2·5 volts. The E.M.F. of these cells is low, under

* Paper read before the City and Guilds of London Old Students' Association at the Technical College, Finsbury, on Wednesday, May 8.

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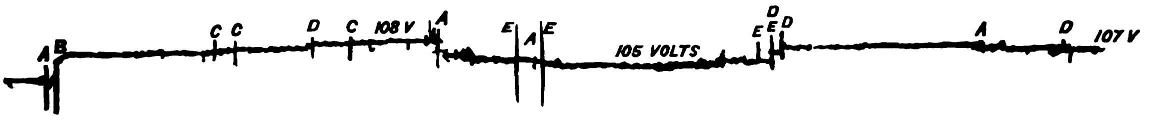
one volt, but there are advantages which more than compensate for this. One very peculiar feature in this battery is that the shaking, such as is met with in tramcar work, is advantageous rather than otherwise. There are many advantages in a cell of this type; for example, a thin metal box is all that is required, no glass or acid-proof linings being necessary. Again, for tramcar and portable work the absence of acid is a great boon, the alkaline solution being comparatively harmless to surrounding wood and metal work.

the negative plate, and reduces the efficiency of the cell. The diagrams shown are facsimiles of E.M.F. curves taken by a recording voltmeter. They are from a large set of 31 L cells, which are charged by a dynamo driven by a gas-engine. When the cells are in use this voltmeter is started, and it records the exact E.M.F. at the terminals of the cells during charge and discharge. You will see how sensitive and accurate the instrument is, and what a valuable record is kept. This instrument is designed by Messrs. Reginald Jones and J. E. Hall, and is



CHARGING SECONDARY BATTERY; CURVE OF E.M.F. BY RECORDING VOLTMETER.

Begins Charging at 107 volts. A, Cell put in; C, Miss fire of Gas-engine; D, Cell taken out; E, Battery circuit broken; B. Engine stops. After A, at left hand, lights from Cells only.

The maintenance of secondary batteries is not difficult when a slight knowledge of the behaviour of the cells is obtained, and if a sharp look out is kept for faults so that they may be remedied before getting too serious. The following remarks on the maintenance of batteries refer chiefly to cells of the E.P.S. type, as they are the only type with which the electrical engineer has to do at present. In charging a new set of cells for the first time it is very important that the charge should be commenced at a slow rate. Some of the cells will need more charging than others, and the charging should be continued till the electrolyte becomes quite white or milky with the gas that is given off. It will not hurt the cells that get to this state first to continue the charging till all the cells are alike, provided the charging current is not too great; if, however, one or two of the cells are much behind the others, it will be advisable to cut them out during the discharge, joining them up again for the next charge. One thing I have found in new cells that should be carefully watched. If any little drops of lead have fallen while burning the lead lugs, and have lodged on the plates, they should be removed; if this is not done they will cause trouble. The condition of a cell can be accurately ascertained by use of the hydrometer, and it is very useful to prepare a table showing the fall in specific gravity of the electrolyte for a given number of ampere-hours taken out of the cell. Care must be taken that the acid density is the same throughout the whole of the electrolyte, or the bulb of the hydrometer may be in a denser part of the electrolyte, and therefore give a higher reading than is correct. The tendency is for the acid to become denser at the bottom of the cell, and this should be prevented by occasionally blowing up the electrolyte with an indiarubber ball or piece of glass tube. If the cells are always charged to gassing, this will not be so necessary. Each cell in a set should be periodically tested with a voltmeter reading to about three volts; this should be done during the discharge, and it will show whether every cell is doing its share of the work. This is also the best way of finding out short circuits, and if the cells are tested when the discharge is nearly completed, it will show which are working up to their full capacity and which are not. A sharp look out should be kept for any appearance of white sulphate; it is easy to get rid of just a little here and there; but when the cell is badly sulphated it requires careful treatment. If a cell is charged at a fast rate when in this condition, gas will be given off from the lead grids instead of oxidising the active material, which is clogged up or coated with the sulphate, and some of the plugs may be forced out. By charging a cell slowly for a long time it is possible to get rid of this sulphate, and as much as possible should be scraped off during the charge with a piece of ebonite, so that the surface of the active material may be exposed to the electrolyte.

Mr. Barber-Starkey has tried with very great success the use of carbonate of soda in the electrolyte to prevent sulphating. He has a set of cells for lighting, which are never charged at the proper rate, and very seldom fully charged, owing to the insufficient engine-power, the current being about 10 amperes instead of 25 amperes. These cells got into a very bad condition in about three months after they were put down, so he put into each cell a handful of common washing soda. They soon got into good condition again, and ever since he has had no trouble whatever with them. They can be left for several months without charging, and are never charged beyond the gassing point. It is now about three years since this was tried, so there has been ample time to test the efficiency of this method. The peroxide plates are in a beautiful condition, and the cells altogether are in as good a condition as when new. This plan has been tried in several places since with great success. It removes two of the greatest objections to cells of this type—viz., the overcharging required, and the impossibility of letting the cells remain idle. If the cells can be cut off directly gas is given off, a great gain in efficiency is effected, as the E.M.F. required to charge them rises slowly as the capacity increases to about 2·1 volts, when gas is given off, and the E.M.F. rises rapidly to about 2·4 or 2·5 volts. This increase of ·4 volt per cell is entirely wasted in overcoming the E.M.F. due to gas on

somewhat on the same principle as the recorder used by Mr. Wright at the Brighton central station. It is manufactured by the Woodhouse and Rawson Electric Supply Company.

Of course, cells should never be discharged at too fast a rate. This will cause the plates to buckle, and the plug of active material to fall out. Buckling, in some cases, is due to the plates being badly constructed, and to their being supported or held in the wrong places. These are the chief points to be remembered in the maintenance of secondary batteries, and I hope you will pardon me if I have been saying things which are already well known to some of you. In secondary battery work especially it is impossible to learn much by reading books or studying chemical formulæ. Experience must be gained by carrying out the actual work, and watching the results of the actions which take place.

Although it may appear to be very easy and simple, yet in carrying out experiments, and trying new ideas, one meets with results which are very misleading and difficult to reconcile with theory. I have endeavoured to put before you some of the lessons which experience has taught me, and I hope they have been in some degree interesting.

ELECTRIC LIGHTING IN LONDON.

The following letter and extracts relate to the Board of Trade Enquiry into Electric Lighting in London. They speak for themselves:

Board of Trade (Railway Department),
London, S.W., May 18.

My Lord,—I am directed by the Board of Trade to transmit to you the enclosed copies of Major Marindin's report made after his enquiry, held by direction of the Board of Trade, into the various applications for provisional orders and licenses under the above-mentioned Acts in respect of the metropolis, as well as into the subject matter of a Bill introduced into the House of Commons by the Metropolitan Electric Supply Company, Limited.

In forwarding copies of this report for the consideration of the County Council, I am to inform you that, subject to any observations that they may wish to offer, the Board of Trade propose to adopt the recommendations of the report with regard to the allocation of the various districts to the several companies.

A description of these areas will be found in the report, from which it will be seen that in the following districts only powers over the same area are proposed to be granted to more than one company—viz.:

St. George's, Hanover-square.

A small portion of the parish of Lambeth to the north of Westminster-bridge-road.

A small portion of the parish of St. Martin's-in-the-Fields to the east of Northumberland-avenue and St. Martin's-lane.

The Board of Trade concur in the opinion expressed by Major Marindin, that looking to the fact that the supply of electricity on the alternating current and transference system cannot be made use of for motors, the competition of a system which can be made useful for motors is desirable, and that, consequently, where powers are granted within the same area to two companies both those companies should not be those using alternating currents. This principle has been adopted in allocating the various districts, except in so far as regards a small portion of the parish of Lambeth to the north of Westminster-bridge-road, which has been allotted to the London Corporation and the Metropolitan Company, both of which propose to use alternating currents and transformers.

The latter company was the only one which proposed to take the whole of the parish, and they are in possession of a site for a generating station in the northern corner of the parish. The whole of the parish was, therefore, allotted to this company, but it was found necessary also to grant powers to the London Company over a portion of the parish in order to give access to the districts allotted to it on the other side of the Thames.

A small portion of the parish of St. Martin's-in-the-Fields has been allotted to the same two companies; but in this instance the latter company possess a generating station in Whitehall-place, from which the supply is by a continuous current.

In two of the parishes allotted to the London Company—viz.,

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Chelsea and St. James's, Westminster—powers to supply electricity have already been granted to other companies by provisional order and license granted in the years 1886 and 1888 respectively. Both of these companies, however, use continuous currents.

In the present orders it is proposed to substitute for the provisions as regards Schedule A and Schedule B, hitherto usually adopted, a provision that the undertakers should be bound at once to lay down mains in certain streets to be scheduled, and that they should be compelled to lay mains in any other streets in the area on requisition by owners or occupiers.

With regard to the question of capital, I am to point out that, while the capital of the various companies would doubtless be wholly inadequate if the entire areas allotted to them required to be lighted at once, they possess, in the opinion of the Board of Trade, sufficient capital to provide for all the work they are likely to be called upon at present to perform.

As regards the maximum price chargeable, the Board of Trade, in the absence of any evidence that such a price would be excessive, propose to adopt the maximum of 8d. per Board of Trade unit. They think, however, that a clause should be inserted providing for a revision of the terms of charge at the end of seven years from the date of the order, and they propose that this clause shall be so drawn as to make it possible to adopt, as regards electrical lighting, the principle of the sliding scale of charge, which has been applied with advantage under the Gas Acts. It is impossible at present to foresee the initial price which it will at the end of that period be reasonable to prescribe; but, following the analogy of gas, and considering that the electric companies only have a certain tenure of 42 years, the Board of Trade are of opinion that a price arranged on the basis of a 10 per cent. dividend would not be unreasonable.

With a view of saving time, the Board of Trade are now going through all the objections raised to the clauses of the orders, and are preparing a model order, which, with the necessary variations for the varying circumstances of different districts, would be adopted for the whole of the applications, and that, as soon as this model order is in a sufficiently advanced stage, a copy will be forwarded to the County Council.

In conclusion, I am to state that as time is of the utmost importance, the Board of Trade would be glad to be favoured with the observations of the London County Council at their earliest possible convenience.

I have the honour to be, my lord, your lordship's obedient servant,

HENRY G. CALCRAFT.

The Earl of Rosebery, London County Council, Spring-gardens.

MAJOR MARINDIN'S CONCLUSIONS AND SUGGESTIONS.

(1) That it must be admitted that the science of electric lighting has now reached the point at which a supply can be made which will be of very great benefit to the public, and that the power of obtaining this supply should be within the reach of all persons who may require it. For this reason it seems to me that although the wishes and opinions of the local authorities in the areas proposed to be supplied should be consulted and deferred to as far as possible, the mere objections by a local authority to the introduction of a company proposing to supply electric light upon general grounds should not be considered sufficient to exclude such company, unless the local authority should express its intention to undertake the supply, and give evidence that it proposes to apply for permission to do so, and this should apply with more force when it can be shown that the exclusion of a company from such an area would injuriously affect the service of other contiguous areas.

(2) That in dealing with this question it should be considered as one affecting the interests of the metropolis as a whole, and as an area which at no very distant time may be for purposes of lighting and management of roads and streets under the control of one central authority; and that therefore the whole of the provisional orders granted for the metropolitan area should, as far as possible, be identical in form, with identical provisions as to supply, compulsory powers, interference with streets, and, more than all, as to price.

In my opinion the scheme adopted in 1883 of dividing the area of supply into two areas, A and B, would not be likely to work so much to the advantage of the public as the proposal in most of the orders under consideration to make the supply compulsory under requisition over the whole area upon equal terms.

I consider, however, that in order to ensure that some work shall be at once undertaken in every parish or district within the area of supply under such order, there should be a list of streets scheduled for compulsory laying of mains, and a deposit made in every case where the local authority may wish to have it.

Where there are two companies in the same area, different streets should be scheduled for each.

With regard to the clauses affecting supply, interference with streets, testing, position of stations and distributing boxes, and other details, the whole of the suggestions made by the local authorities should be carefully weighed, and those which are considered necessary embodied in the model form of order.

With regard to price, I do not consider that any one district in the metropolis should be put in a better position than another.

Taking the area as a whole, it does not appear that it would be wise to fix a lower maximum than 8d. per unit.

It is true that the London Company is now supplying at 7½d., and the maximum in the St. James's and Pall Mall Company's license is 7d., but these companies are competing in an exceptionally good area.

There would, however, appear to be a necessity for a reduction of the high rate for minimum supply, that is, the sum which every customer taking a supply can be called upon to pay, irrespective of the amount which he has consumed, and which in the orders varies between £3. 6s, 8d. per quarter in the case of the Notting Hill Company, and £5. 10s. in the case of the Metropolitan Company's South London order.

The latter company has consented in the Mid London and West London orders to reduce the minimum to 13s. 4d. per quarter, and I consider that whatever minimum is fair should be adopted throughout.

The provision for revision of price after each seven years, in the agreements between the Metropolitan Company and the Strand and Marylebone local authorities, seems to me to be somewhat contrary to the policy of Parliament when dealing with the Electric Lighting Act. If any such provision be inserted it should be general; and it would appear to be more fair that the revision should take the form of a sliding scale upon the basis of a 10 per cent. dividend, the standard being fixed after the experience gained by the working of the first seven years.

It has been suggested that in the matter of price the consumer should, if he elects himself to pay the whole cost of connecting his house to the mains, have no minimum at all imposed upon him; but, although I can see no objection to this proposal, such a provision would hardly be necessary where the minimum is reduced as in the metropolitan orders.

(3) That in every case the supply of electricity, whether by a company or by a local authority, should be under statutory obligations as well as statutory powers, by means of a Bill, a provisional order, or a license.

(4) That there is no objection to the granting of a large area of supply to any company which shows that it has sufficient capital and is capable of coping with the demand. On the contrary, a large and rich company is likely to be the best and most economically managed concern, to be able by working over a large and scattered area to develop the demand for the light, and by rapidly increasing its business to be the sooner in a position to reduce the price of the article supplied.

(5) That in the abstract competition is desirable, as tending to keep down the price, and to cause the manufacture and supply of electricity to be carried on with all the attention and energy which it is possible to devote to it.

The competition with gas, which at present at any rate, and probably for many years to come, will appeal to a totally different class of customer, will not be nearly so effective, while the potential competition from the power of calling in a new company in an area badly served is not likely to be called into play until the bad service has passed through many degrees, and has reached a very low ebb indeed.

The question as to how many companies should be granted concurrent powers in one area requires more consideration.

In cases where the local authority objects to the entrance of any company, and it is decided to overrule the objection, I think that one company should only be granted powers.

In cases where two or more companies have obtained the assent of the local authority, the following facts must not be lost sight of:

1. That the laying of the mains of several companies up one street means so much dead capital, and, moreover, the provision of a certain amount of useless material, which the local authority would have to pay for if it should decide to purchase the undertakings after the lapse of 42 years.

2. That no matter what regulations or stipulations may be made as to the laying of mains, the interference with the streets, and the consequent inconvenience to the public, must be in a certain degree proportionate to the number of companies having powers over these streets.

For these reasons, I am of opinion that, for the present, powers should not be given to more than two companies over the same area, and, inasmuch as the companies supplying under the alternating current and transformer system cannot supply electric energy capable of use for motors, that both of these two companies should not be those using this system.

In order, therefore, to leave room for the entrance of a direct supply company into an area where two alternating current transformer companies have been assented to, it will be necessary to choose one only of these companies, and this will lead to a certain amount of districting.

(6) That wherever a company now supplying a district by means of overhead wires is granted an order for such area, it should be placed under the obligation to remove these overhead wires within a period of two years from the granting of the order; and, if such a thing be possible, that this company should be prevented from invading a district in which it has not got powers by means of overhead wires.

(7) That in order to reduce as much as possible the disturbance of streets, clauses should be drafted making it obligatory for companies to lay their mains in existing subways, and to transfer them into subways which may be made in the future upon being called upon to do so.

If possible, it would also be advisable to provide that wherever circumstances admit of it, and where there is no subway, the conduits put down to lay the mains should be made capable of accommodating the mains of both companies in the area, if there be two companies having powers therein.

To a certain extent, also, it would appear to be right that the local authorities should have the power of objecting to the sites for generating, as distinguished from distributing stations, subject to an appeal to the Board of Trade.

Applying these principles to the orders asked for by the several companies, I recommend the Board of Trade to adopt the following course in each case:

I. The London Electric Supply Corporation.—As this company and the Metropolitan Company are competing in many parishes and districts, and are both companies working with alternating currents, unable at the present time to provide for motive power, the areas applied for should be districted, and I propose, therefore, to allot to

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the London companies and to include in the London order the following parishes and districts :

The portion of St. Martin-in-the-Fields lying to the south of the Strand and west of St. Martin's-lane ; the portion of St. Margaret and St. John, Westminster, lying to the north of Victoria-street, excepting that portion of St. Margaret's lying to the west of St. George, Hanover-square ; St. James, Westminster ; St. George, Hanover-square ; Chelsea ; the Greenwich district ; St. Mary, Rotherhithe ; St. Mary, Bermondsey ; the district of St. Olave ; the district of St. Saviour, Christchurch ; and that portion of St. Mary, Lambeth, lying to the north of Westminster-bridge-road.

The only dissenting local authorities in the above areas are the Vestries of St. James, Westminster, of St. Mary, Lambeth, and of St. Margaret and St. John, Westminster, and the District Board of St. Saviour's, but of these the first two would, judging from the statements of their representatives at the enquiry, consent, if their objections be, in the opinion of the Board of Trade, fairly met ; and it should be pointed out to them that, while St. James's would under the terms of the order gain by the compulsory removal of the overhead wires with which the London Company is at present largely supplying in the parish, it is in the case of St. Mary, Lambeth, essential to the continuity of the London Company's area that this company should have the means of passing through the northern end of the parish.

This last reason applies equally to the parishes of St. Margaret and St. John, and the opposition of the united vestry of these parishes was not so strong as to lead to the belief that it would object to the division of the parishes as I propose between two companies, especially as there appears to be a demand for electricity in the district.

The district of St. Saviour's, after assenting to the granting of the order, withdrew the assent, but did not appear at the enquiry to give any reasons for so doing, and as the district intervenes between other portions of the London area, the local authorities of which have assented and wish for the supply of electric light, I submit that the objection of St. Saviour should be overruled.

The case of St. James and St. John, Clerkenwell, is difficult to deal with. This parish is cut off from the district which I propose to allot to the London Company, and the Metropolitan Company has abandoned the North London order, in which it was included, while the Vestry has assented to the entrance of both companies.

If the City should consent to allot a district to the London Company, giving access to Clerkenwell, this parish should be added to the London area, otherwise it might be suggested to the Metropolitan Company to adhere to their North London order so far as this parish is concerned.

The general form of the clauses of the order should be similar to those in the other orders for the metropolitan area, and it will be better to deal with all the suggestions and requirements of the local authorities on this head generally, when the principles upon which the orders are to be granted have been considered and determined ; but there are two special clauses in the London order which have already been alluded to, and might be dealt with separately.

I do not see any objection to clause 55, authorising the supply to a local authority of electricity in bulk, provided, in the opinion of the legal authorities, it be possible to place the local authorities under the obligations of the order by any such clause.

As to clause 56, I think that, subject to the subdivision of the generating station at Deptford, as recommended on page 19 of this report, it would be a mistake to reduce the cubical dimensions of the building.

A compliance with the recommendations on the above-mentioned page should be a condition upon which the granting of the order should depend.

II. The Metropolitan Company.—To this company I would recommend that the following area should be allotted :

Under the Mid-London Order.—St. Giles-in-the-Fields ; St. George, Bloomsbury ; St. Andrew, Holborn-above-Bars ; St. George the Martyr ; St. Sepulchre ; Saffron-hill ; Hatton-garden ; Ely-rents and Ely-place ; the Liberty of Glasshouse-yard ; St. Ann's, Soho ; St. Paul, Covent-garden ; St. John the Baptist ; Savoy or precincts of Savoy ; St. Mary-le-Strand ; St. Clement Danes and the Liberty of the Rolls ; together with the extra-parochial places known as the Charterhouse, Gray's-inn, Lincoln's-inn, Staple-inn, and Furnival's-inn.

The whole of the local authorities in the above area assent to the order.

Under the West London Order.—St. Marylebone, the vestry of which assents to the order.

Under the South London Order.—St. Mary, Lambeth, St. Leonard, Streatham, and Clapham.

Neither of the local authorities affected—viz., the Vestry of St. Mary, Lambeth, and the Wandsworth District Board—has signified its assent, but both would probably do so if their objections be met in a manner considered fair by the Board of Trade.

Under the Bill.—That portion of St. Martin-in-the-Fields which lies to the east of Northumberland-avenue, Charing Cross, and St. Martin's-lane.

The Vestry of St. Martin-in-the-Fields assents to the Bill.

With powers in this area, the Metropolitan Company will have access from the main portion of the Strand district to the outlying portions, and will also have powers over some portion of the parish of St. Martin-in-the-Fields, contiguous to their existing station in Whitehall. In the latter portion, although the company will be competing with the London Company, there will not be two alternating current companies, as the supply from the Whitehall station is by continuous current.

The only area in which there will be two competing alternating-current companies is in North Lambeth, where it cannot well be avoided.

III. The House-to-House Company. IV. The Notting Hill Company.—I recommend that the areas as agreed to between these companies and the Vestry of Kensington be approved of and the orders granted in suitable terms.

V. The Kensington and Knightsbridge Company.—Similarly in the case of this company, I recommend that the area as agreed to between the company and the Vestry of Kensington be approved of and the order granted.

With regard to the part of the parish of St. Margaret, Westminster, applied for, I recommend that the order be approved of subject to the consent of the vestry. This body has decided to object to the powers which are being exercised under licenses granted by consent being extended to those given by provisional order ; but I trust that the matter may be so represented that this decision may on reconsideration be altered.

VI. The Chelsea Company. South Kensington Order.—This order is assented to by the Vestry of Kensington, and I recommend that it be granted for the area agreed to.

Belgravia Order.—In the case of this order I see no valid reason for dispensing with the consent of the vestry, which has been withheld. Consent has been given to the orders of three other companies.

VII. The Westminster Company.—Although the scheme of this company is in a somewhat incohate condition, the Vestry of St. George's, Hanover-square, has assented to the order. The Vestry of St. Margaret and St. John, Westminster, withholds consent ; but for reasons already given I consider that powers over part of the area asked for in this district should be given, the existing station of the company being in this area.

I recommend that the order be granted for the parish of St. George, Hanover-square, and the portions of St. Margaret and St. John, Westminster, lying to the south of Victoria-street. This company has abandoned the remainder of the area originally applied for.

VIII. The Electrical Power Storage Company. Paddington Order. In view of the objection of the vestry, and its expressed intention to undertake the lighting of the parish, and for other reasons given below, I cannot recommend that this order be granted.

St. Martin's and Strand Order.—The Vestry of St. Martin's assents, and the Strand District Board dissent to the order.

The company applying for these orders is a company manufacturing batteries and other electrical appliances, and it seems more than doubtful whether, under the articles of association, there is any power to undertake the manufacture and supply of electricity for house-to-house lighting purposes. However this may be, it is perfectly clear from the evidence of the manager of the company that the company does not intend to exercise the powers which would be granted by the order, but to transfer them to some other persons.

I have no doubt that these persons are perfectly willing and competent to carry out the powers and obligations of the order, but I submit that it would be quite contrary to practice to grant an order to any but a properly-constituted company, proved to be in a position to act under it, and as this has not been done, I cannot recommend that the order be granted.

It should be understood that in every case the recommendations to grant these orders is on the understanding that the whole of the works both at the generating and other stations, and along the mains, are to be planned and executed in a manner such as to satisfy the Board of Trade that the public are properly protected, both as regards safety, and, so far as may be possible, from any extinction of the light for an appreciable time, and that, should it be found impracticable to carry out the districting between the London and Metropolitan Companies in the manner which I have proposed, the whole question will be reconsidered so that the areas may be fairly readjusted.

The Metropolitan orders for the Strand and Marylebone should be in as nearly as possible the same form as those applying to other parts of the metropolis, as there does not appear to be any sufficient reason for treating these areas differently from any others.

The only districts applied for in which I have decided not to recommend the granting of orders, as amended, are the parishes of St. Pancras and Paddington, where the local authorities should, I think, be granted time to decide definitely whether or not to carry out the lighting of their parishes under the powers of a provisional order ; and the City, which, although not exempted from the operation of the Electric Lighting Acts, is in a somewhat different position from other parts of the metropolis.

The Commissioners of Sewers, acting for the Corporation, are endeavouring to obtain tenders for the lighting of the City, but I see no reason why the principle that all such lighting should be done under statutory powers and obligations should be departed from in their case.

If the Board of Trade should agree in this view, I would urge the Commissioners of Sewers to consider whether the orders, as remodelled, do not sufficiently provide for all their requirements, and in that case to consent to the division of the area of the City between the two competing companies—viz., the London and the Metropolitan Companies, the latter company being allotted the portion nearest to the Strand district, and the former the central and eastern portions of the City, so that access may be given to the parish of Clerkenwell, the vestry of which wishes for an order to be granted to this company.

In addition to the above-mentioned provisional orders, the two licenses applied for by the Chelsea Company and the House-to-House Company have to be considered. These licenses are both for areas included in the portions of the parish of Kensington allotted to the companies respectively by the vestry, and the consent of the vestry has been given.

Subject to any alterations in clauses which may be found necessary to make the provisions of these licenses similar to those of the provisional orders applied for, I can recommend that for the purpose of expediting the commencement of the works, they be granted.

I have the honour to be, Sir, your obedient servant,

F. A. Marindin, Major, R.E.

I concur with the above report. P. Cardew, Major, R.E.

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SECONDARY BATTERIES.*

BY WILLIAM HENRY PREECE, F.R.S.

(*Concluded from page 373.*)

Central Stations.

The secondary battery lends itself admirably, under certain circumstances, to the economical distribution of electric currents from central stations. It is possible to lay down a long main circuit of small dimensions, conveying a direct current of high E.M.F., which at different points can charge a secondary battery of a small number of cells, so as to "transform" the dangerously high E.M.F. into one of a low and harmless character in the building to be illuminated. In fact, this is now being done in Chelsea by two different companies. The one company, the Chelsea Electricity Supply Company, is acting under the statutory powers of a provisional order, and it distributes its currents to the houses from sub-stations, where the batteries are kept and maintain a continuous supply of electric energy. Each sub-station, of which there are three, supplies current for 2,000 30-watt 10-c.p. lamps. There are 265 31-L cells, divided in two sets of groups of 53. Each set is charged separately and alternately in series from the central generating station. While one set is being charged the other is supplying currents to the consumer. The main charging current of 60 amperes has an E.M.F. of 500 volts per distributing station, or 1,500 volts for the present circuit; and the secondary discharging supply into the houses has a pressure of 100 volts. This system of distributing currents from batteries has many advantages. The currents, being direct, are available at once for motor purposes, as well as for lighting. The currents being so steady and uniform, add to the durability and life of the lamps. The supply being continuous day and night, it is always available, just as is the light from gas. The distributed currents being of low E.M.F., absolute safety to person is secured in such a system. The engines at the central station being always worked at full loads, can be worked under their most economical conditions; and as they can be worked continuously throughout the 24 hours, a minimum capital expenditure in engine plant is necessary. It has already been pointed out that the efficiency of the battery is not much affected by variations of its own load, and that whether one lamp or 100 lamps be used it is of not much consequence to the cells; in fact, the efficiency of the lighter load is the highest. On the other hand, it must be pointed out that there is a considerable capital outlay required in batteries. The depreciation of the cells is very considerable, and there is an appreciable loss of energy at each transforming point. The maximum efficiency of batteries in practice rarely reaches 70 per cent., while less than 15 per cent. for depreciation can scarcely be allowed with prudence. The batteries for 1,000 lamps cost £1,325, or 27s. per lamp. The reliability, constancy, and permanence of the light from batteries compensates for many another evil. The other company in Chelsea—the Cadogan Electric Supply Company—places the batteries in the houses, and charges 1,000 E.P.S. 31 L cells over a circuit of nine miles.

There is a central station in Detroit, in the U.S.A., also distributing by batteries, and giving great satisfaction.

The Kensington Court central station, established by Messrs. Crompton and Co., and that at Whitehall-court, also use secondary batteries, but the batteries are in the stations, and not in the houses. They are used more for regulation and for reserve force purposes than for distribution.

There is a large central station at Vienna, and one at Darmstadt of the same character.

An extremely ingenious mode of distribution has been proposed by Mr. Henry Edmunds. The battery is divided into four groups. Three groups are jointed in series, and supply energy to the house, while the fourth group is in the main being charged. These groups constantly and continuously changed places every three minutes by means of an automatic switch. A third of the battery is, therefore, always being charged, and this means that only one-third engine-power is needed at the central station, and only one-third of the E.M.F. on the changing main. Mr. Edmunds's automatic distributor is an extremely ingenious apparatus, but it has not yet received the test of practical trial, though the sooner it does so the better.

Traction.

A very important application of secondary batteries is that of traction. In the United States this system has received immense development, but in England it has scarcely as yet grown out of the experimental stage. In London the North Metropolitan Tramways are trying some important experiments, but in Birmingham an electric locomotive has been made by Elwell-Parker on the Julien principle, weighing 8½ tons, and worked by 100 cells, each weighing 81 pounds, which has drawn loads of 30 tons up stiff gradients, and has run 70 miles with only one charge. This system is destined to be most useful and economical, and it looks as though it would gradually replace horses for tram work.

Portable Lamps.

Two other useful purposes to which secondary cells are applied are (1) the construction of safety lamps for miners, and (2) reading lamps for railway travellers. Since one pound weight will give a capacity of four ampere-hours (and it is easy to obtain lamps which can be incandesced with only the third of an ampere), it follows that if we use three cells each weighing one pound, we can easily get a lamp which can be maintained alight for twelve hours giving a light of about two candles. This is ample for both purposes enumerated; in fact, I habitually travel with such a portable railway reading lamp, and find it of immense service. The battery that I am now showing to you was charged during the last Christmas holidays. I have not travelled since, and it has not lost much of its charge, as you plainly see. I have much pleasure in exhibiting several forms of safety miners' lamps, which have been lent me for the occasion by Mr. Pitkin, their manufacturer. Mr. Swan has done much in this direction, and his lamps are in considerable use, especially in South Wales, and are now exhibited in action.

Telegraphy.

All attempts to use dynamos direct for telegraphic purposes in England have failed, but their use indirectly, by means of secondary batteries, has been eminently successful. At the General Post Office, in London, there are 220 circuits thus worked from only 38 cells. The currents used for telegraphy are very minute compared to those used for electric lighting; ·05 ampere, or 50 milliamperes, is a large current for such a purpose. Thus the current that would light one 50-watt glow lamp will work 10 telegraphic circuits. The secondary cells are applied thus: 20 cells provide motive-power for Delany multiplex distributors, and 120 single needle circuits; 18 cells, or 2 parallels of 9 cells, provide currents for 100 direct inker Morse circuits.

This mode of working has now been in since the early part of 1884.

It is quite clear that the secondary battery has passed through the experimental stage, and that it has now reached its commercial career, where it will prove to be a most valuable and indispensable adjunct to the equipment of the electrical engineer.

* Paper read before the Society of Arts, May 1. This subject has been before the society on two occasions. In 1881 (vol. xxx., p. 30) Prof. Silvanus Thompson read a paper on the "Storage of Electricity"; and in 1883 (vol. xxxi., pp. 1,025, 1,038), Prof. Oliver Lodge, F.R.S., gave two lectures on "Secondary Batteries."

ALTERNATE CURRENT WORKING.*

BY W. M. MORDEY.

I wish to state at the commencement that this paper is not intended as a contribution to the comparison of the relative merits of alternate-current working, and of any system of direct-current supply. The discussion of this question has already taken place, and those who took the A.C. side have no reason to be dissatisfied with the result. It may, however, be pointed out that exclusive advocacy of any one particular method of working, as being the best for all purposes, is not a position that is likely to be taken by any electrical engineer who has any extensive acquaintance with the various requirements and conditions that are met with in practice.

Working Alternators Parallel, and Best Principles of Construction for Alternators.

This is a matter of very great scientific interest, and of still greater practical importance. It is not too much to say that the complete success of the transformer system of supply depends to a great extent upon whether alternators can be quite easily and successfully worked parallel. This has been strongly insisted upon, especially by the opponents of that system. The importance attached to it arises partly from the fact that the most economical method of supply is that of using always the smallest plant that will do the work, and increasing or decreasing the number of generating units in operation, according to the fluctuations of the demand. To do this most conveniently, the alternators should be worked parallel, and ought to be capable of being put in and out of circuit easily, and without causing even a momentary flicker or interruption of the light. The use of a large machine and engine for the small day supply is especially to be avoided. In almost all cases it is desirable to have a comparatively small set of plant for this work, even where large machines are used for the heavy evening work.

Another argument in favour of parallel working, as against the use of very large machines, is that it reduces the cost of the spare plant. Thus, if a station is provided with one or two machines and engines for the full load, the spare plant is equal in cost to the working plant, or, perhaps, to one half as much. If, however, smaller generating units are employed, one set in four may be considered a safe allowance.

The history of parallel working of alternators may be briefly sketched.

In 1868 Wilde described parallel working and synchronous action of generators, and so nearly obtained synchronous motor action that it is extraordinary he should have missed it.†

In 1882-3 Dr. Hopkinson,‡ not knowing of Wilde's work, arrived theoretically at the conclusion that it was possible to work alternators parallel, but not in series, and subsequently demonstrated the fact by trials made, in conjunction with Prof. Adams, on the De Meritens machines at the South Foreland Lighthouse, which were run parallel and as motors. This was all laid before this society at the time, and was very fully discussed.§

In the course of this discussion in 1884, Mr. Alexander Siemens described some experiments showing that the Siemens alternate-current machine ran as a motor.‖ This is interesting as being, so far as I know, the only recorded instance of an alternator without iron in the armature being run as a motor. It will be remembered that the Wilde and De Meritens machines had iron cores. These experiments of Mr. Siemens were not very successful, the motor frequently stopping suddenly, even when doing very little work; but they were of value for comparative purposes.

* Paper read before the Institution of Electrical Engineers.

† "On a Property of the Magneto-Electric Current to control and render Synchronous the Rotations of the Armature of a number of Electro-Magnetic Induction Machines." H. Wilde, *Phil. Mag.*, Jan., 1869, pp. 54-62.

‡ *Proc.* Inst.C.E., 1882-3.

§ *Journal*, xiii. (1814), pp. 496-559. ‖ *Journal*, xiii., p. 525.

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Passing over the next few years, we find that the use of alternators had become of great importance on account of the growth and development of the transformer method of distribution, and that there was and is a certain amount of doubt and hesitation about working parallel. It is recognised that it has been and can be accomplished, but that the arrangement is not one to be thoroughly and completely depended upon in every case. And there is sufficient justification for this doubtfulness. The present opinion may be fairly stated as follows: Alternators may be successfully run in parallel if they have a good deal of self-induction, and to secure this it is better that they should have iron-cored armatures.

In his recent paper on "Alternate Current Machinery," before the Institute of Civil Engineers,* Mr. Kapp dealt at considerable length with this part of the subject, and his views, I need not say, may be accepted as quite correctly representing the current state of knowledge and opinion. Referring to alternators that have self-induction, negligible Mr. Kapp says: "Machines of this type can only be run in parallel if the strength of their field is adjusted with almost mathematical precision, and as this would require more skill and attention than is available with the ordinary staff of a central station, such machines are practically unfit for parallel working. To make them fit for this method of working, either the armature resistance or the self-induction must be increased. An increase of resistance in order to be effective, would have to be so considerable as to seriously prejudice the electrical efficiency of the machine, and this expedient may therefore be dismissed as impracticable. The other plan of increasing the self-induction is not open to the same objection. It has the effect of lowering the plant efficiency, but its influence upon the electrical efficiency is only indirect, and so small that it may be neglected. From the foregoing, it will be readily seen that the only and sufficient condition for successful parallel working is a sensible amount of self-induction in the armature circuit. If the armature itself does not possess the quality in a sufficient degree, a choking coil of suitable self-induction must be inserted into the circuit of each machine. The results here arrived at, by a mere theoretical investigation, are entirely borne out in practice. It is well known that alternators having no iron in their armatures cannot be run in parallel, except by the adoption of some such expedient as choking coils; also that parallel running is feasible with those alternators which have iron-cored armatures, and then with different degrees of security."

Now this is a very serious state of affairs, for it really means, if true, that the only machines suitable for central station supply are those that, on account of their high self-induction and resistance, are bad regulators that will not bear any considerable change of load without varying a good deal in E.M.F., and that are wasteful on open circuit.

For my part, I have seen enough of the use of iron in armatures to wish to do without it if I can, and I have repeatedly pointed out that, if iron is really necessary, the armature is the very worst place to put it. For the purpose of increasing the self-induction, it can be much better used outside of the machine, and put in some place where it is not subject to all the losses, restrictions, and disadvantages that necessarily accompany its employment in the core of an armature. If it is not in the armature, it can be entirely removed when not required for the purpose for which it is thought to be necessary—that is, when only one machine is in use. To put iron in an armature merely to increase self-induction, appears to show a want of common ingenuity and an absence of the sense of proportion.

But let us examine the evidence on this matter, in order to see what basis of fact there is for the present views.

In the first place, it will be found that the use of iron armatures is not in all cases to be relied on to give successful parallel working. In the discussion last year, Mr. Gordon, who has had very considerable experience, and who used iron largely in his machine, warned us in strong terms against working in parallel. He said:† "We know that experiments have been made by coupling a number of small alternate-current machines together, and at the South Foreland they were successful, but that was because they were working on arc lamps."

A little elucidation, perhaps, is necessary here—"Many of us have tried them, and they will, on trial, work together, no doubt, but they do not work together till they have run for three or four minutes. They will in that time jump, and that jumping will take months of life out of the 40,000 lamps. That alone is rather a serious difficulty in coupling machines together, and I think we may take it in practice—I am not speaking about the laboratory or experiments—that we do not couple machines."

The Zipernowski alternator will, however, work parallel, but apparently not very well. To get it to do so, the periodicity has had to be reduced to 42, as we now know.‡

Further, I have recently seen a communication from the highly-experienced makers of a well-known alternator in which iron is used, stating that, if it is desired to run parallel, the machines, engines, and arrangements must be in every way identical, the impression conveyed being that with this machine the greatest care is necessary to ensure a successful result.

Then, again, the large experience of the Westinghouse Company in the United States has shown that their iron-cored alternators will work in parallel under some conditions. We are told that, with these machines, "parallel coupling always succeeds when they are loaded to about half their maximum output or over, but that machines working under a less load cannot with certainty be so coupled."

But the other day Professor Forbes described§ successful parallel working with the iron-cored Lowrie-Parker alternators at West Brompton, even with very light loads.

* *Proc.* Inst.C.E., February, 1889.
† *Journal*, xvii., pp. 195-6, February, 1888.
‡ See under "Periodicity."
§ Board of Trade Enquiry. April, 1889.

Thus it will be seen that we have evidence ranging from complete failure to complete success with iron-cored machines.

It is proved, then, that the presence of iron is not alone sufficient to ensure success, for the use of iron is associated equally with failure and with success.

That the success attained is complete only as regards the fact of synchronism, is shown by the following extract from Prof. Forbes's remarks in the discussion on Mr. Kapp's paper, which I quote at some length, because Prof. Forbes has taken every opportunity of ascertaining by personal observation what is being done, and because he gives us what is alone of much service at the present stage—viz., the independent record of actual facts, and tells us clearly what the real difficulties are.

The passage is:* "The question of parallel working was one which had been very much discussed as to whether it was desirable or possible. . . . It was always possible, as Mr. Kapp said, with machines which had a very high self-induction—machines in which the armature had a great mass of iron in it. At the same time, the introduction of that self-induction into a machine reduced what Mr. Kapp called the plant-efficiency of the dynamo machine; and if they could work out, as he believed engineers would work out, some better means of making machines work in parallel, it would be very desirable.

Another reason why the heavy self-induction was injurious, was that it required such continued attention on the part of those in the station to see that the pressure was maintained constant. The electrical pressure varied so much, that the quantity of current being developed, as shown by the table of curves (Fig. 11) was seriously affected, and constant attention was required to keep such a machine regulated to the right pressure; whereas a machine which had no self-induction, or very little, gave off the same electric pressure, or nearly so, whatever the current might be, so long as the speed was maintained constant. As to the possibility of working conveniently in parallel with those machines, he might say that the experience of America had been completely against it. It was there found that it was possible to work in parallel, but that it enormously increased the amount of skilled attention required in a central station."

This is a very strong condemnation of the present system of obtaining synchronism, and at the end of his "Central Stations" paper† Prof. Forbes returns to the subject in these words: "I venture to think, however, that the plan now universally proposed for making machines work in parallel will not long be tolerated. This is to introduce into the machine a large amount of injurious self-induction, thus diminishing the plant efficiency, and rendering the equalising of pressure with various loads very difficult."

Turning now from alternators with to those without iron-cored armatures, we are brought face to face with the serious fact that, in spite of the many inconveniences connected with the use of very large machines, Mr. Ferranti is laying down the Deptford station to work with engines and alternators, each of several thousands of horse-power, and is depending upon the employment of spare engines and machines, of corresponding size, to prevent or to minimise the risk of wholesale extinction of the lights. It is understood that one of the principal reasons for doing this is that parallel working is not to be relied on.

The next question is, is it clear that, in order to be able to run them parallel, or as synchronising motors (for I need not say that the two qualities are inseparable, and are, in fact, identical), alternators should be bad regulators, should have large self-induction, or high resistance, or both? I think not. I have mentioned Mr. Gordon's machines, which certainly had the first of those qualities, but they would not run parallel. Other machines that I have referred to, and whose parallel working is not to be depended upon, are, at any rate, not remarkable for absence of self-induction.

Again, is the absence of iron from the armature cores alone sufficient to deprive a machine of self-induction, and to give it a straight characteristic? I think not; for I have tested machines that had no iron, but that had a good deal of resistance, very considerable self-induction, that had very crooked characteristics, and yet that would not run parallel under any circumstances whatever.

So we see that neither a bent characteristic, nor self-induction, nor resistance, nor the use of iron cores, nor even the simultaneous possession of the whole of these admirable features and qualities—that none of these things is the secret of successful parallel working.

Perhaps—and this is a dreadful reflection—it is the exact opposite of all these!

Now I am in the unenviable position of being out of accord with the theories, the practice, the principles, and the explanations of the very able men who have lately written, spoken, and worked on this subject. I have no doubt that all they have said is perfectly correct, so far as their difficulties are concerned—that they have experienced considerable trouble in working parallel, and have even in some cases met with actual failure. But this was partly because they have been unfortunate or unwise in the apparatus they have used, and partly because the principles that have been relied on to ensure success have not been in all respects suited to the case.

Although the conditions of the two problems are not in all points similar, I very respectfully submit that we are in danger of repeating the old mistake that was made regarding direct-current motors. We were taught that self-induction in the armatures was good, and that a special form and special proportions should be given to such motors; and I was very unorthodox when, in 1886,‡ I asserted that self-induction was not a virtue to be cultivated in motors any more than in dynamos, and, generally, that a good motor was a good dynamo—and *vice versâ*. However, it is some satisfaction to know that the

* *Proc.*, Inst.C.E., February 19, 1889.
† *Journal* xviii., p. 195.
‡ *Phil. Mag.*, Jan., 1886, "The Dynamo as a Generator and as a Motor."

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views I then expressed have received the sanction of general practice, although I am afraid that in the eyes of Profs. Ayrton and Perry those views remain as unorthodox as ever.

(*To be continued.*)

BOARD OF TRADE ENQUIRY.

Major Marindin, C.M.G., R.E., on behalf of the Board of Trade, resumed the enquiry at the Westminster Town Hall, for the purpose of hearing, on the part of a number of electric lighting corporations, their provisional orders to erect and maintain electric lines and works, and to supply electricity within certain areas in the metropolis and elsewhere, and the objections raised thereto by other companies and corporate bodies.

WEDNESDAY, APRIL 24.

Mr. J. B. Martin, one of the directors of the Westminster Electric Supply Corporation, Limited, called and examined by Mr. Wallace, said that the capital of the company was £100,000. All the portions of the city of Westminster had been abandoned during the enquiry with the exception of St. Margaret's, St. John the Evangelist, and St. George's, Hanover-square. The capital had been subscribed for the purpose of arranging for sites and the fitting up of some small plant near Victoria-mansions, which would cost about £8,000. The directors of the company were Lord Suffield, Sir John Heron Maxwell, Mr. Henry Kimber, M.P., Mr. H. Fisher, M.P., and himself. A great many of the gentlemen who had subscribed capital to the company were owners of property in the district of Westminster. They had engaged three sites for the supply of electricity, and were negotiating for two others for their battery stations. Two of them were wharves. They had entered into a contract for erecting plant with two large firms—Messrs. Crompton and Co. and Messrs Latimer Clarke, Muirhead, and Co. The parishes of St. Margaret's and St. John were to be lighted by Messrs. Crompton and Co., and the parish of St. George's, Hanover-square, by the other firm. Adjoining their property at Victoria-mansions a site had been purchased which was intended to be used as a battery site, and the plant there would be used as an auxiliary plant if required. The boilers had already been put down, and the other portions of the machinery would soon be delivered, which would supply about 5,000 lights.

Cross-examined by Mr. Pember, he said that they were registered as a company for the supply of electric light, which was to be their real business. They had no special patents to sell. He thought there were about 20 shareholders. It would not be difficult for him to give their names. He could supply them next morning. The value of their shares was £10 each. He held £50,000 himself. He might mention that that was not the maximum capital that they had power to raise. The present installation that they were fitting up would cost £8,000, and would supply 5,000 lights. The contracts they had entered into were for a much larger amount and a much larger district. They had arranged for 100,000 lights at so much per light. They had entered into contracts to supply certain areas at 35s. per light inclusive.

Mr. Latimer Clarke, examined by Mr. Wallace, said that his firm had had considerable experience in manufacturing electrical appliances, as well as in laying underground mains for telegraphic purposes. They had erected plant at St. James' station, which had commenced working, but not on a proper scale. There was a contract entered into with his firm for the supply of electric plant for 40,000 lights for St. George's, Hanover-square. That contract was based on so much per light. He thought that from the time of getting the order it would take six or seven months before the installation was completed. They would be able to supply 20,000 lights in about four months' time.

Cross-examined by Mr. Pember, he said that their estimates were about 30s. a light; but they had made a provisional contract, which was to be settled thereafter by arbitrators. There was nothing to prevent an arbitrator giving more than 35s. a light. They were to be paid in money. There was no provision for taking shares in the company.

By Mr. Moulton: Their system was the ordinary three-wire system, assisted by batteries at the outside stations.

Re-examined by Mr. Wallace, he said that his firm had so arranged matters that if there should be any exceptional work its cost was to be settled by arbitration.

In further reply to Mr. Pember, he added that they had told Mr. Martin that he could erect the whole of the lamps for 30s., and they were prepared to do their part of it at a price which would enable him to buy the sites and complete the work at that price.

Mr. K. Hedges, engineer to St. Stephen's Club, examined by Mr. Wallace, said that he had three clients anxious to take the light—the St. Stephen's Club and two other establishments belonging to the Aerated Bread Company. They would prefer to have it on the direct system with storage batteries. There would be a great demand for the electric light in the vicinity of Westminster on the direct system with storage batteries.

Cross-examined by Mr. Pember: It was a *sine qua non* at the present time that at St. Stephen's Club the light should be on that system. They had applied to the Metropolitan Company before that company was wired—some 10 months ago. The cause of the change that had come over their ideas in the matter of system was that the light at other clubs had failed. He had been told by the club officials that that was the reason. At a meeting of the committee he was asked whether, in his opinion, the system supplied by the Grosvenor Gallery Company would be sufficiently reliable, and he said he did not think so under existing conditions. He had mentioned in a little work of which he was the author that the alternating system was suitable for large areas. It was very much a matter of expense. There was no impossibility in point of principle or practice.

Mr. F. W. Anderson, electrician to Messrs. Latimer Clarke, Muirhead, and Co., examined by Mr. Wallace, deposed that his firm had erected the stations at St. James', which had worked satisfactorily. At present there were no batteries there. For St. George's, Hanover-square, it was proposed to have a battery supply.

Cross-examined by Mr. Graham, he said that the cells they proposed to use as a stand-by were the E.P.S. For an installation of 40,000 lights there would probably be four stations, each covering 10,000 lights.

Mr. Muirhead then opened his case on behalf of the St. James' and Pall Mall Electric Light Company, and said that he objected to the application of the London Electric Corporation, and also of the Metropolitan Company. His company was started in the St. James' district because there was great dissatisfaction in the parish at the unsatisfactory lighting on the part of the Grosvenor Gallery Company, and it was at the request of a great number of people in the district that a new company should be formed which should devote its attention to their requirements. The parish might be divided into two areas. First of all, there was the area to the south of Piccadilly, which contained all the clubs and a great many public buildings, which would require long hours of lighting. To the north of Piccadilly there was a poorer district, which was inhabited by working people, who required motive power, so that when the St. James's Company designed their system of supply they resolved to establish two stations—one in the south and one in the north. In the southern portion of their area the station was specially adapted for lighting purposes. In the northern the station was to be established for the purpose of supplying power, but in order that the northern station should be of use in the general system, the machinery was designed so that when the current was turned off in the northern portion of the parish it could be utilised in the southern to assist the machinery there at the time of the maximum supply. Soon after the incorporation of the company they applied for a license, and after prolonged negotiations with the parish the license was granted by the Board of Trade in December last. He might here say that the St. James's Company did not intend to go beyond the boundary of the parish, and they desired to meet the whole of the requirements of the parish. Having that object in view they had accepted all the amendments to their application proposed by the Vestry. The capital of the company was fixed at £100,000, but they had, of course, power to increase it. At the time the company was started a prospectus was sent out to the public setting forth the objects of the company, and while the subscription list was still open the Grosvenor Gallery Company—he had no doubt to protect their own interests and to try and prevent the successful floating of the St. James's Company, which was going to be a powerful competitor—issued a map to the public covered all over with red patches to show that the ground was practically occupied. That, however, did not affect the floating of the company. £28,000 was subscribed in the first instance, and the number of shareholders on the list was about 60. The company then purchased a site in Mason's-yard, the cost of which was £9,500. They spent on the construction of the building £8,500, and entered into a contract for the supply of machinery for 10,000 lights, at a cost of £18,500. That contract was divided into two sections. The first was for 5,500 lights for £11,000, and the second brought up the lights to 10,000 for £7,500. The first portion of the contract was now practically completed, and the company was about to lay down the first section of the mains. The system adopted by the company was the low tension and the machinery was subdivided in a manner similar to that of the Metropolitan Company at Whitehall. The system of distribution was known as the three wire, and the company proposed to establish a net work of mains through every street in the southern half of the parish. There would be a ring main running down St. James's-street, along Pall Mall, up Regent-street, and Piccadilly, connected by means of feeders with the station. He did not think it would be necessary for him to call any scientific witnesses as regarded the system of distribution and machinery, as they were well known, and beyond minor matters of regulation he did not think the machinery possessed any novelty.

Mr. Eustace Balfour, chairman of the board of directors of the St. James's Company, examined by Mr. Muirhead, said he was an architect by profession, and had paid personal attention to the erection of the machinery at Mason's-yard. His company proposed to confine its operations entirely to the parish of St. James's, and proposed to adapt themselves to the requirements of the public. They had acquired the freehold site at Mason's-yard, the capacity of which was for 35,000 lamps of 10 c.p. With accumulators he was told that they could supply any number up to 80,000 lights. They had commenced operations, and the light had given great satisfaction. They had met all the objections of the Vestry, and a license was granted to them in December last. Their system was the three wire, with a voltage of 110. Their district contained all the best clubs, and there were a great many rich people lived in it, and there were other public places, such as large banks and fine shops. They anticipated a large amount of lighting in the area. It was his opinion that for such a district special arrangements for lighting had to be made. They had no transformers, but eventually the company proposed to use storage batteries. Their boilers were specially constructed, the engines being of the Willans type, while the dynamos were supplied by Messrs. Latimer Clarke, Muirhead, and Co. He anticipated no nuisance from smoke or vibration. They would have no difficulty in finding what capital they required.

Cross-examined by Mr. Pember, he said that they could work without batteries, but it was intended to use them. They wished to have the batteries in hand in case of a breakdown. He was an enemy of competition in the sense that every company starting under the favourable auspices under which they started ought to have a chance in its

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own district of satisfying the Board of Trade. Of their £100,000 nominal capital £28,000 had been subscribed. The directors were Mr. Hemmerde, Mr. Kirby, Colonel Francis, Mr. Royds, Mr. Latimer Clarke, and himself

Mr. James Hemmerde was next called and examined and cross-examined by counsel, principally with regard to the financial arrangements of the company, which concluded the cases of the applicants for provisional orders.

VESTRY OBJECTIONS.

The second stage of the enquiry were now entered upon—namely, the hearing of the objections raised by the various vestries to the granting of the provisional orders applied for—which lasted, practically, four days.

The first case was that of the Rotherhithe Vestry, represented by **Mr. Stokes**, who did not object to the preamble of the order, or to its general scope, but demanded protecting clauses in respect to the breaking up of the streets, the making of sewers, and the employment of overhead wires.

Mr. Nash, on behalf of the parish of Paddington, stated that the special objection there to the proposed orders was that the vestry were anxious to undertake the lighting of their own area themselves. Some months previously Prof. Forbes had reported on the subject, pointing out the cheapest and most effective way of lighting the district, and stated that there would be many advantages to the district if the vestry obtained the power itself.

Mr. H. L. Cripps, who represented the Strand Vestry, said that there were five companies applying for provisional orders to light their district, and the Strand Board, after considering which company, from its general position, was most likely to meet the requirements of the locality, decided on entering into the agreement with the Metropolitan Company already referred to. The points of that agreement were first, the definite appropriation of the different stations as the source of light in the district; second, the definite allocation for distributing mains over the entire area in positions agreeable to the local authority: third, the security that from such stations and mains an adequate supply of electricity would be produced for the district; fourth, an easy means of detecting the cause of any failure or deficiency in the supply of the district; fifth, an easy access to headquarters to lodge complaints and obtain a remedy; sixth, definite arrangements for preventing obstructions in the streets; seventh, the relief of the Board of Trade from the task of arbitrating between the local authority and the company with regard to works in the streets; eighth, freedom of the consumer from various onerous conditions with regard to obtaining a supply, and arbitrary powers contained in the provisional order; ninth, a system which pointed as far as possible to a harmonious working between the local authority and the company. The Strand Board thought that consent to the London Electric Supply Corporation's application ought to be withheld on the ground that jointed mains would involve a greater disturbance of the streets than the system of the Metropolitan Company.

Mr. R. W. Young, representing the Wandsworth District Board, said they wanted a clause to prevent the buying up of any company that might in future compete with the Metropolitan Company. They also recommended that the area of the generating stations should be circumscribed, and that some sliding scale should be incorporated in the order. They further suggested that, instead of 8d., the price inserted in the St. James's order—namely, 7d.—should be substituted.

Mr. Wilkins spoke on behalf of the St. James's Vestry, and said that their main consideration was whether they should adopt the principle of free trade or of districting. They had come to the conclusion, after mature consideration, that the principle of districting was as essential with regard to electric lighting as it ever had been in respect of gas, especially in view of the fact that there were now no less than 15 companies which had authority to lay mains in some of their streets. He thought that the whole of Mr. Ferranti's evidence pointed to the conclusion that the system proposed by the London Electric Supply Corporation was experimental. The dynamo to be used was larger than any yet constructed; the rigid concentric main was to be jointed at every twenty yards, which would be its weakest part; while the high tension of 10,000 volts had never been tried even on a small scale, and the corporation proposed to work with it over a distance of seven or eight miles. Consequently, after prolonged enquiry, the Vestry had adopted the St. James's Company, which used the continuous current at low tension, and the Metropolitan Company, which was already doing work in the parish at a moderately high tension on the alternating system. It was claimed for the Deptford scheme that there would be a net economy in the cost of production of 43 per cent., but at the same time he found that the London Electric Supply Corporation sought power to charge 8d. per unit, whereas the maximum price of the two companies assenting to the terms of the Vestry was only 7d.

Mr. Hitchins appeared for the parish of St. George's, Hanover-square, and examined **Mr. J. H. Smith**, the clerk to the Vestry, who stated that the London, the Metropolitan, the Westminster, and the Chelsea companies wrote asking for provisional orders to light the parish. Subject to certain amendments, the Vestry had no objection to the orders of the first three of these; but, in consequence of some correspondence that passed between them and the London Company, the Vestry had passed the following resolution: "That the Vestry do now approve of the application of the London Electric Supply Corporation, Limited, for a provisional order to enable the corporation to supply electricity in this parish, but upon the express condition that the corporation accept all the alterations and conditions which have been insisted upon by the committee acting on behalf of the Vestry, and that the order should be so amended as to clearly and distinctly embody the same."

Mr. Hewitt, who addressed the inspector on behalf of the Kensington Vestry, said that there were six companies competing for the district, two of which—the London and the Metropolitan—had withdrawn their applications. He desired to point out that it was most desirable that before generating stations were created in the district the sanction of the local authority should be obtained. The companies who proposed to light Kensington were not to be regarded in the light of benefactors, but merely as speculators engaged in a very lawful enterprise, and he ventured to think that the views of the local authority in matters of this kind should be fully considered.

Mr. H. L. Cripps said that the Vestry of Marylebone opposed the application of the London Company. The scheme which that company had adopted would entirely defeat, when the time came for its operations, those provisions of the Electric Lighting Act which ultimately enabled local authorities to acquire the undertaking. The Metropolitan Company had approached the local authority of Marylebone with suggestions for an arrangement which appeared to be satisfactory. If the Board of Trade sanctioned the order applied for by the London Company as regarded parts of the parish, it would operate in a way which seemed to him would be very unreasonable, inequitable, and inconvenient. If it were granted, the effect would be that the Metropolitan Company would be placed in competition in the best part of the district with the London Company.

The parishes of St. Margaret's and St. John's, Westminster, were also represented by **Mr. H. L. Cripps**, who stated that as regarded the London Company's order his board had had an opportunity of inspecting the works at Deptford, and had obtained all possible information, and were of opinion that it was desirable that electric light works should, as far as possible, be kept out of large centres of trade and business; and that public authorities should be placed upon more favourable terms in respect to public lighting than they now were.

Mr. Coates, representing St. Pancras Vestry, said that they had got powers under a provisional order granted in 1883 to light the whole of the parish of St. Pancras, and being entirely independent they considered that no company should be allowed to go into their district and compete with them because they were more likely to make the lighting pay than any company would be, because they would have no dividend to pay, and could raise money for the purpose at 3½ per cent.

Mr. Moulton stated that the telephone companies said that they required a clause inserted in all the orders ensuring electrical quietude in the metropolis.

Mr. Russell Griffiths, on behalf of the City authorities, opposed the granting of a provisional order to either the Metropolitan or the London Company, which concluded the cases of the local authorities.

COMPANIES' MEETINGS.

MAXIM-WESTON ELECTRIC COMPANY.

The statutory ordinary general meeting of the Maxim-Weston Electric Company, Limited, was held on Thursday in last week at Winchester House, Old Broad-street, E.C., under the presidency of Mr. John Marks.

The **Chairman** said there was no resolution to be submitted to the shareholders; but, as they had had to be called together, he would take the opportunity of making a few remarks. In the first place, they had, unfortunately, lost the services of two Directors Mr. Harvest had been taken away by death, and Mr. Hildyard had resigned because his business required the whole of his time and attention, and he therefore felt he could not do justice to the work of this Company. Of the 312,000 shares at their disposal on the reconstruction of the Company 262,000 were applied for, so that only 50,000 remained. These the liquidators had requested the Directors to offer to the shareholders, if they were disposed to take them. At the time the applications were made for the new shares a large number of shareholders applied for more than they were legally entitled to, and the Directors could not, therefore, allot them. If those shareholders were now desirous of tendering for them, or any portion of them, on the understanding that the tender would be for the extra 1s. per share not paid up, the Directors would be happy to consider their applications. If they did not apply, the Directors could place everyone of those shares within 24 hours. The applications must be made within seven days of the issue of the circular, which was being prepared. The dissentients in the old company numbered from 24,000 to 25,000 shares, but he was happy to say they had been able to arrange a settlement with those dissentients on terms fair to them and to the new Company, and there would be no litigation whatever in regard to them. The Directors had secured the services of Mr. Hamilton as general manager, and he believed at the end of the financial year they would be able to come before the shareholders and give a good account of their stewardship. They had concluded some contracts, and others were under negotiation. One they had concluded was for 1,000 lights, and it was likely to lead to greater results. The Directors considered the Company in a very satisfactory position. The end of the financial year, he added in reply to a shareholder, would be at the end of March next.

The proceedings then concluded.

WOODHOUSE AND RAWSON, LIMITED.

An extraordinary general meeting of the shareholders of this Company was held last Friday at the City Terminus Hotel.

Lieutenant-General Sir John Stokes, who presided, stated that the advance in electrical work which he mentioned at their meeting last December had continued, and during the past few months there

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had been a great extension of electrical enterprise in all directions. Their business was steadily progressing, and their installation work was fully appreciated. When they considered the large amount of central station work that was being done in London with 21 central stations, and in other parts of England and the Continent, the outlook was very encouraging. Their general business had steadily increased outside of electrical work, and they had taken out and acquired several valuable patents, chiefly electrical, during the past year. Abroad, there had been a gratifying increase in their business. With regard to the Elmore patents, in which they were interested, the Elmore Patent Copper Depositing Company, which he mentioned at the last meeting, had been successfully brought out, and the statements made as to the value of the process had since been more than proved. The proposed amalgamation with, and the sale of their undertaking to the new company was on the lines approved at the last meeting—that they received now their dividends up to June 30 last, together with a bonus of 10 per cent. upon the amounts paid up on their shares from the new company. In addition certain assets were to be distributed among them. By the sale to the new company the founders' shares would be done away with, thus enabling the payment of larger dividends. The distribution now proposed would make 12 per cent. for the year. He concluded by moving the adoption of the accounts and the declaration of the dividend mentioned.

Mr. Lambert seconded the motion, which was carried; and a resolution was afterwards passed approving the agreement for the sale of the undertaking of the Company to a new company for shares and debentures of the latter.

NEW COMPANIES REGISTERED.

Bahia-Blanca and North-Western Railway Company, Limited.—Registered by Ashurst, Morris, Crisp, and Co., 6, Old Jewry, E.C., with a capital of £2,000,000 in 13,500 preferred and 6,500 ordinary shares of £100 each. Object: to acquire, construct, complete, and equip, maintain, prolong and work railways and their appurtenances, tramways, lines of telegraph, telephones, or other means of communications, or appliances of a similar nature in the Argentine Republic, and for such purposes to enter into and carry into effect any contracts, and apply for, accept and carry into effect such concessions or authorities as may be deemed necessary or desirable; to acquire mining powers, rights or easements over any railway, tramway, or line of electric wire, or other similar means of communication. The first subscribers are:

	Shares.
J. Holliday, Sudbury-villas, Peckham	1
J. Hunt, 16, Dover-street, Piccadilly	1
A. Baker, 135, Gladstone-road, Wimbledon	1
E. Wade, 4, Lindore-road, S.W.	1
C. Bloomfield, Acton	1
T. Winter, 9, Bowness-road, Catford	1
E. Botwright, 23, Sutton-place, Hackney	1

The number of Directors shall not be less than three nor more than seven, the first to be appointed by the subscribers to the memorandum of association. Qualification: £500. Remuneration: £3,500 per annum, divisible as they determine.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended May 17 amounted to £4,932.

Western and Brazilian Submarine Telegraph Company.—The traffic receipts of this Company for the week were £3,544.

West India and Panama Telegraph Company.—The receipts of this Company for the half-month ended May 15 were £3,141, against £2,852.

United Telephone Company, Limited.—The Directors recommend a dividend for the half-year ending April 30 at the rate of 12s. 6d. per fully paid share, less income-tax, making, with the interim dividend, a total distribution for the 12 months of 17½ per cent.

Consolidated Telephone Construction and Maintenance Company, Limited.—This Company, in their report for the year ending March 31, shows a profit balance of £13,286. The Directors propose a further dividend of 7 per cent. for the half-year, making, with the interim dividend, 6 per cent. for the year, writing off £520 for depreciation of plant, machinery, and furniture, and £2,000 from goodwill, patent rights, etc., leaving £1,558 to be carried forward.

PROVISIONAL PATENTS, 1889.

MAY 13.

7919. **Improvements in apparatus for making certain articles of pottery-ware, such as electric lamp roses, switches, fuse blocks, and the like.** Richard Thomas Grocott, Longport, Staffordshire.

7947. **Improved method of crossing the ends of drum armatures of dynamos.** John Farquharson, Pomona House, King's-road, Fulham, London.

7976. **Improvements in arc lamps.** Sebastian Ziani de Ferranti, 24, Southampton-buildings, London.

7948. **Improvements in bleaching paper pulp by electrolysis.** Emile Marie Hippolyte Andreoli, 62, Loughborough-park, Brixton. (Complete specification.)

MAY 14.

7992. **Improvement in combined telephony and telegraphy.** Herbert John Allison, 52, Chancery-lane, London. (James Hart Robertson, United States.) (Complete specification.)

7993. **Improvement in exchange or central office systems as applied to telegraphs, especially autographic telegraphs.** Herbert John Allison, 52, Chancery-lane, London. (James Hart Robertson, United States.) (Complete specification.)

8030. **Improved automatic switch for charging electric accumulators and like purposes.** Max Emil Unger, 89, Chancery-lane, London.

8046. **Improvements in electrical fire-alarms.** Henry Edward Newton, 6, Bream's-buildings, Chancery-lane. (William Birchall, Victoria.) (Complete specification.)

8053. **Improvements in electrical signalling apparatus.** Oliver Imray, 28, Southampton-buildings, Chancery-lane, London. (Alfred Walker Jones, Benjamin Franklin Jones, and Edward Lowe Martin, United States.) (Complete specification.)

MAY 15.

8070. **Improvements in telephonic switching apparatus.** Alfred Rosling Bennett, 62, St. Vincent-street, Glasgow.

8113. **Improvements in or applicable to electrical cells or batteries.** Henry Edward Joël and John Stephen Cassal, 226, High Holborn, London.

8115. **Improvements in the thermo-magnetic generation of electric currents and in apparatus therefor.** William Henry Snell, 70, Chancery-lane, London.

MAY 16.

8143. **Improvements in instruments for measuring electric currents.** Philip Jolin, 35, Narrow Wine-street, Bristol.

8157. **Improvements in switches for electric signalling apparatus.** Leopold Sellner, 45, Southampton-buildings, London.

8195. **Improved arrangement for paying out drums for laying submarine cables.** Richard Harnett, 65 and 66, Chancery-lane, London.

MAY 17.

8213. **Improvements relating to the method and means employed for coupling alternating current dynamo machines in synchronal relation, and to the control of motive power engines used for driving the same.** Wm. Lowrie and Charles James Hall, 433, Strand, London.

MAY 18.

8290. **Improvements in electric switch boxes, ceiling roses, and other articles, where it is desirable to have two glass, earthenware, or porcelain parts, such as a box and lid, screwed or attached together so as to permit of easy detachment.** George Crosland Taylor and James Taylor, 6, Lord-street, Liverpool.

8318. **Improvements relating to dynamo-meters.** August Ackermann, 4, South-street, Finsbury, London. (Date applied for under Patents Act, 1883, Sec. 103, 20th October, 1888, being date of application in France.)

SPECIFICATIONS PUBLISHED

1888.

5811. **Generating, &c., electric power.** Crompton and Swinburne. 8d.

7408. **Electrical fuses for firing blast holes, &c.** Boult (Manet and another.) 6d.

9672. **Dynamo-electric machines, &c.** Lowrey and others. 11d.

1889.

2071. **Electric systems.** Ferdinand. 8d.

2952. **Electric relay apparatus.** Lake (Dressler.) 11d.

4722. **Electric conductors.** Lake (Griggs.) 8d.

4800. **Electric conductors.** Lake (Brooks.) 6d.

5095. **Secondary batteries.** Haslam. 6d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	5/8
27 July	10/0	India Rubber, G. P. & Tel.	10	18
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply ...	5	3⅜
......	...	Swan United	3½	2⅜
12 July	12/0	Telegraph Construction ...	12	42
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15½

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NOTES.

Buenos Ayres.—A central station is now in progress at Buenos Ayres for a total of 30,000 Edison lamps.

Peru.—A long-distance telephone line has just been opened by an English company from Callao to Lima, in Peru.

That's the Way.—A law has just been passed in the State of Michigan enabling gas companies to go into electric lighting.

Prague.—A central electric light station is to be erected for the Municipality of Prague by the firm of Waldek and Wagner, of that town.

Chelmsford.—The contract of the Town Council of Chelmsford with Messrs. Crompton and Co. for the public lighting of Chelmsford was sealed on Wednesday.

Smoking Concert.—The next smoking concert of the O.S.A., the final one of the season, is to be held on Saturday, June 15, at the Manchester Hotel, Aldersgate-street, at 7.30 p.m.

C & C Motors.—It is interesting to note that small electric motor work is not standing still. We understand that Messrs. Shippey Bros. have sold over 1,100 C & C motors in Great Britain and France during the last six months for driving ventilating fans, sewing machines, and other similar purposes.

Brighton.—We learn that Mr. Albert Gay, late of Taunton, who was recently appointed manager at the Eastbourne electric light station, has now been appointed manager to the Brighton and Hove Electric Light Co. A new central station will be erected shortly at Brighton, under the new manager's superintendence.

Liverpool Tramways.—One of the accumulator cars of the Electric Traction Company now at Barking-road will be sent shortly to Liverpool to test upon the tramways in that town. The gradients in Liverpool are rather steep, but there is probably little doubt that electric storage cars will eventually be adopted on these tramways.

Bank Lighting.—The Bank of Africa have determined to introduce the electric light, and have placed the order with Messrs. Drake and Gorham, who have had probably the largest experience of any contractors in this particular class of work. A 4 h.p. Otto gas-engine will be employed to drive a 5-unit Elwell-Parker dynamo for charging 33 of the firm's latest cells.

Havanna.—A central station has just been completed at Havanna by a Spanish-American company. The Westinghouse alternating system is employed for the incandescent lamps, with the Waterhouse system of arc lamps. The 1,500 incandescent lamps already installed are much appreciated. Westinghouse engines are used, of 130 h.p. for the incandescent lamps, and 75 h.p. for the arc lamps.

China.—The Chinese papers mention that electric lighting is becoming general in all their large cities, and is gaining ground in the smaller places. Pekin, Hong Kong, Shanghai, Canton, and other large cities have now a considerable number of lights. At Victoria, the capital of Hong Kong, we learn that a public company has been formed, and the machinery for a central station has just been ordered from Messrs. Johnson and Phillips.

Where was the Paper?—Where was the paper? and who was it by? are the questions that were asked at the Society of Arts on Tuesday. The paper on the Westinghouse System, said the notice, was to be by Mr. James S. Humbird: the *Journal* said it was by Mr. O. B. Shallenberger: the secretary announced it would be read by Mr. Belfield. But the paper didn't turn up, and nobody knows who it was by and what it was about to this day, as far as we can learn.

Holborn District.—The Works Committee of the Holborn District Board reported that they had received an application from the Gwynne-Pilsen Lighting Company for consent to supply electricty within the Holborn district. They recommended that the consideration of the subject be deferred until the report of Major Marindin has been made in reference to the electric lighting schemes referred to him to enquire into. The matter was referred back to the committee.

Old Students' Association.—The next meeting of the Old Students' Association is to be held at the Central Institution, South Kensington, when a paper will be read on "The Economical Use of a Primary Battery, based upon the Recovery of Zinc," by P. G. Nicholson, F.C.S., member. The paper will deal with the history of the Lalande battery; E.M.F., etc.; products of chemical reactions in cell; methods of recovering zinc as chemical compound; methods of recovering zinc as metal; and probable economy of the process.

Paris Congress.—The International Congress of Electricians, to be held at Paris, in August, during the time of the Exhibition, will not undertake, as has been thought possible, any redetermination of the standard ohm. This congress is not definitely under Government authority, and any action of this kind could only be taken authoritatively by the continuation of the previous congress of 1881, under the French Government. This will probably be held in 1891, when the question of the value of the real ohm, it is anticipated, may be definitely settled.

Train Lighting.—The Midland Railway Company began on Wednesday night to use the electric light on the system mentioned last week, the light being used for the first time on the London and Manchester and Liverpool express. The system of separate accumulators and couplings allowed the train to be broken up as desired, and the dynamo was found to be easily regulated. During the stoppage of the train to change engines the light was kept perfectly steady by the accumulators. The lamps are of 8 c.p., two in some compartments, and four in others. The appearance of the carriages was very brilliant, and the trial was a perfect success.

Temporary Lighting.—On Wednesday evening last Messrs. Woodhouse and Rawson, Limited, carried out a very successful example of temporary lighting at the Drapers' Hall. The permanent lighting of this hall is also under their maintenance, but on the above-mentioned occasion the light was required for the courtyard. This was covered over with a canvas roof, and in the centre, where the drapery was suspended from a centre ring, a large paper Japanese umbrella was hung, from the points of which were dropped 40 10-c.p. lamps, making a very effective electrolier. Below this was a large terra-cotta basin filled with beautiful exotics. The surrounding corridors were lit by suspended lamps in ornamental shades. The current was supplied from 53 E.P.S. cells of the 23 L type.

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Acid Proof Material.—We are asked for further information with reference to the new acid proof material for lining accumulator cells referred to on p. 416 last week, in the paper on secondary batteries by Mr. Appleton. A correspondent remarks that if such a material is available at not too great cost it will be a great boon, adding that he has a large battery of Planté cells which has become quite useless from leakage, and has tried almost every means to prevent it. We believe we are not telling secrets when we state that this valuable material, which can be bent about and moulded like indiarubber and soldered almost like lead, is a special material manufactured for this purpose, which Messrs. Appleton, Burbey, and Williamson will shortly introduce under a license from the patentee.

Proposed Telephone Convention.—In a circular published last week by the *Electrician*, issued by Dr. Julius Maier, calling attention to a telephone convention to be held in London on July 11, 12, 13, it is stated that the proposed convention has been organised by the representatives of the telephone companies and the Post Office. This statement of the status of the convention should be contradicted at once. We understand that the Post Office have taken no part whatever in the convention, and it is in no way under their authority or initiative. We believe the mistake has arisen from the fact that Mr. W. H. Preece has consented to be present, but this is in a private and electrical capacity, and not as a representative of the Post Office, who consistently refuse to lend their authority to meetings or conventions.

Telegraph Signalling Station.—The movement to have a telegraph signalling station on Tory Island, off the north-west of Ireland, says the *Financial News*, is again being pressed. It is stated that a traffic of £38,000,000 annually passes, the vessels engaged employing a quarter of a million of men. The lighthouse, visible 30 miles off, is the first thing sighted by homeward-bound vessels taking the northern route; but the absence of a telegraph seriously reduces the value of the outpost. The "Bolivia," with broken main shaft, once lay off the island two days before a stray tug carried news of her need of assistance to Buncrana, the nearest telegraph office. Some merchants interested propose to give a guarantee of 2½ per cent. on the capital involved for three years, to encourage the Government to make the necessary outlay, about £4,000.

Electric Launches.—One of Immisch's electric launches was to be seen at Messum's, at Richmond-on-Thames, last week, and a very neat and handsome boat she is. This one is about 25ft. long, though others are made up to 75ft. A comfortably fitted cabin, furnished with velvet seats and paddings, takes about half the space at the back, and in front, in the open space, are seats on both sides of the boat. Under these the storage cells are placed, and the electric circuits lead to a strong and neatly finished switch with three levers for different speeds. The same arrangement is fitted inside the cabin, so that the vessel can be controlled from either inside or out. Power is obtained from two propellers fitted to Immisch motors, and the motion on the river is very quiet and unobtrusive—a great improvement to both those in the launch itself and those in other boats.

The Woodward Storage Battery. — Messrs. Shippey Bros., Limited, have been appointed sole agents for the Woodward Electrical Company of Detroit, for the sale of the Woodward storage battery. From accounts in the American Press the battery is coming into considerable use in the States. The company have recently extended their works, and have now facilities for turning out some 1,000 cells a week. The battery is really formed of a spongy lead plate, and it is claimed by the makers as being the only practical one of this kind, dispensing with the grid. In manufacture, molten lead is poured into a vessel containing salts, round which the lead solidifies. The salts are afterwards dissolved out, the solid block being sawed into plates. The Woodward battery, which is also known as the Detroit battery, is already in considerable use for traction work, and is said to stand a very heavy rate of discharge. A considerable number of these batteries are on their way to England, when users in this country will have an opportunity of testing their capabilities.

Edison and Swan Company.—The Edison and Swan Company inform us that the directors have resolved for the present to give up installation work, and confine themselves practically to the manufacture of lamps, fittings, and instruments. These branches of their business will be considerably extended, and the company hope to obtain as much credit for their electrical fittings and instruments as they have obtained for the Edison-Swan incandescent lamps. The company intend to manufacture fittings of the best workmanship even if obliged to charge a somewhat higher price than is charged for inferior articles. They have made arrangements with Messrs. Mather and Platt, of the Salford Iron Works, Manchester, to undertake the installation work which they have heretofore carried on. Messrs. Mather and Platt have been sole manufacturers for the company of the well-known Edison-Hopkinson dynamo, and will continue to make the same under license from the company, as well as their own Manchester dynamos. Mr. Blackburn, who has been the Edison-Swan Company's resident engineer for some years past, has, as we have already mentioned, now joined the staff of Messrs. Mather and Platt.

Telephone Amalgamation.—The amalgamation of the three large telephone companies, the United, the National, and the Lancashire and Cheshire will take place, it is stated, by the purchase of two of them by the third, the purchasing company giving its shares in payment. As the licenses held by the companies extend to the whole of the United Kingdom, any one is sufficient to cover the business of all three companies when amalgamated. The National Company is the one selected to absorb the others, as its shares stand nearest to par in market value; but, owing to legal considerations, the National Company's shares can only be taken at their par value, it is therefore necessary to nominally reduce the figures originally proposed as the basis of the amalgamation, which were the then market price of the shares, by one-sixth all round. The figures will then be as follows: The National Company's ordinary shares representing the purchase price are taken at par, £5; the United Telephone Company £12. 10s. for each share; and the United Telephone Company £1. 6s. 3d. for each share of the Lancashire and Cheshire Company. The new arrangement will take effect as from May 1 this year.

The Weymersch Primary Battery.—Some time ago we published a very favourable report of the Weymersch primary battery, and have since mentioned that the India Rubber Company, of Silvertown, were making

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arrangements to manufacture it. They have now issued a price-list which contains an illustrated description of this battery, which, as most of our readers know, is one which is held to be suitable for supplying a fairly large current to small electric light installations for train lighting, or for driving motors where a dynamo is not available. The battery, as arranged, is made with six cells in an ebonite trough, with stoneware taps and flexible tubes, to allow two barrels of the charging solution to be placed near, and so dispense with the usual trouble of refilling, the battery being charged or emptied by merely turning the taps. The E.M.F. of the battery is 13 volts; the internal resistance of the six cells is 0·30 ohm, and the current available is 15 amperes. A thoroughly well-arranged primary battery, even if burning zinc, is very desirable under certain conditions, and the Silvertown Weymersch battery will, no doubt, prove exceedingly convenient.

Annual Dinner.—The annual dinner of Messrs. Crompton and Co., Limited, is fixed to take place to-day (Friday, May 31). Amongst others who have accepted invitations are the following: Messrs. Absalom, A. Court, Alabaster, J. S. Brown, C. H. W. Biggs, S. Bright, J. W. Board, A. Burton, A. G. Brown, Brunton, T. O. Callender, F. Chancellor, B. Drake, R. S. Erskine, Evans, Fyers, Fraser, Basil Gee, G. A. Grindle, Granville Ryder, Gorham, G. Gilkes, T. E. Gatehouse, C. O. Grimshaw, T. Godlee, Gibson, R. B. Hayward, R. F. Hayward, Hoyle, Hamilton, H. S. Holt, Hall, T. W. Hollick, Wilson Hartnell, Izard, A. B. W. Kennedy, G. Kapp, McFarlane Gray, F. Medcalf, Morgan, J. A. Fleming, Newington, Captain Holden, Preece, Paxman, A. H. Pott, Price, Pischon, F. R. Reeves, Rogers, Rawson, M. Robinson, Reckenzaun, J. H. Scrutton, P. E. Scrutton, J. Slater, Selby, H. Stevenson, Statter, Scott-Moncrieff, Sully, S. Stokes, C. E. Spagnoletti, J. Swinburne, Seckham, Shoolbred, I. A. Timmis, Thornton Unwin, S. Waters, F. Whitmore, T. Whiffen, Weston, H. U. Wollaston, M. J. M. Williams, N. G. Wells, Wakeford, and Woodruff. It is expected that altogether rather more than 100 guests will be present.

The Edison Combination in America.—The Edison combination, alluded to some time ago, has now been incorporated in America with a capital of 12,000,000 dollars. The name of the new company is the Edison General Electric Light Company, and it will acquire the stocks of the Edison Electric Light Company, and the three Edison manufacturing companies—viz., the Edison Machine Works, the Edison Lamp Company, and Bergmann and Co. Arrangements are also being made to acquire stock in the Sprague Electric Railway and Motor Company, should it be found desirable to do so. The new company pay partly in cash and partly in stock, the purchase price of the three manufacturing companies being calculated equal to a capital sum in which their net earnings, as shown in their books for the year ending November 1, 1888, will show a profit of 15 per cent. In order to add greater security to the project, dividends will only be paid on the old stock at first, dividends on the remainder being postponed until the directors are of opinion that at least 8 per cent. has been earned. Mr. J. B. Williams is president of the new corporation, and Mr. J. H. Herrick, who will take an active part in the management, is vice-president. No change will occur in the *personnel* of the companies, which will be carried on as departments of the consolidated concern.

Experiment with Mordey Alternators.—The value of Mr. Mordey's work in electrical engineering is greatly enhanced by the clear and able manner with which he gives his results and his conclusions to his colleagues in the electrical world. It was not sufficient for him to state what could be done in paper last week at the Institution, but the members were invited to see the actual experiments on a practical scale carried out at the Brush Company's works on Friday morning last. The visitors were met by Mr. Garcke, Mr. Mordey, Mr. Raworth, and other members of this company, and shown the Mordey Victoria alternators working as generators in parallel, and also as motors. The load put on the alternator whilst the visitors were present was about 25 to 30 h.p.; but we are informed that since then the alternator has been equally successfully run as a motor working at 50 h.p. As Mr. Mordey has fully explained his views in his paper, we shall refer our readers to the paper itself for a description of the experiment. With regard to the heavier load above mentioned, Mr. Garcke says: "We were not able to put so large a load on the machines on Friday, but took the first opportunity of doing so, and a continuous run has fully demonstrated the truth of the views set forth in Mr. Mordey's paper that a properly-controlled alternator would work equally well and equally efficiently, whether its output is mechanical or electrical—that is to say, whether it is a motor or a generator."

Board of Trade and Parliament.—In the House of Commons, on Thursday last week, Sir G. Campbell asked the President of the Board of Trade whether Mr. Calcraft's letter of May 18 regarding electric lighting in the metropolis correctly expressed the present intention of the Board of Trade to adopt Major Marindin's proposals to set aside the provisions of the Act of Parliament of 1888 requiring the previous consent of the local authority in many cases; whether the Board of Trade had approved the proposal of Major Marindin that the mere objection by a local authority should not be considered sufficient to exclude any company unless the local authority was itself ready at once to undertake the supply of electricity, and gave evidence of its intention to do so, and whether that alone would be a sufficient ground for a special report in each case stating grounds for dispensing with the consent of the local authority as required by the Act; and whether, in case he finally determined to give concessions to companies without the consent of the local authorities, he would take care that his special report on each case was laid before Parliament in sufficient time. Sir M. Hicks-Beach replied that Mr. Calcraft's letter correctly expressed the present intention of the Board of Trade. Major Marindin's report, however, did not go so far as is suggested in the second paragraph of the question. If in any case the consent of a local authority is dispensed with, the special report of the Board of Trade will be laid at the earliest possible moment before Parliament. It would not be consistent with the provisions of the Act of 1888 to insert in any provisional order any clause injuring or restricting the subsequent granting of a license or provisional order to the local authority or any other person within the same area.

The Conversazione of Electrical Engineers.—The annual conversazione of the Institution of Electrical Engineers was held last Friday by invitation of the president, Sir William Thomson, and Lady Thomson, at the rooms of the Royal Institution of Painters in Water-

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Colours, Piccadilly, and proved to be one of the most successful of these social gatherings ever held amongst the profession. The guests numbered 735. Nearly all the leading members of the Institution were present, and among visitors who were non-members were the following: Sir Arthur Blackwood, K.C.B., Sir James Crichton Browne, L.L.D., F.R.S.S. (L. & E.), Sir Henry Doulton, Sir Thomas Sanderson, Sir John Coode, K.C.M.G., Sir Juland Danvers, K.C.S.I., General Eccles, Admiral Fitzroy, C.B., Captain Creak, R.N., Captain E. M. Shaw, C.B., Colonel Sir James Grant, C.B., F.R.S., Captain Fisher, R.N., Major Marindin, R.E., Captain Boyle, Dr. G. C. Wallich, Prof. Frankland, F.R.S., Dr. John Rae, D.C.L., F.R.S., Dr. Gordon Hardie, Prof. Hering, Prof. H. Robinson, Dr. William Pole, F.R.S.S. (L. & E.), Dr. J. H. Gilbert, F.R.S., Dr. W. N. Perkin, F.R.S., Prof. W. N. Hudson, M.A., Prof. H. E. Armstrong, F.R.S., Dr. W. J. Russell, F.R.S., Prof. James Grove, F.C.C., Dr. Hugo Müller, F.R.S., Prof. Hulme, F.R.S., Prof. Meldola, F.R.S., Prof. G. J. Romanes, L.L.D., F.R.S., Prof. Govier Seeley, F.R.S., Prof. John Milne, F.R.S., Prof. Hales, M.A., Prof. G. T. Bonny, F.R.S., Prof. W. Ramsay, F.R S., Dr. Bell, F.R.S., Mr. J. G. Symons, F.R.S., Sir Lowthian Bell, Bart., F.R.S., Lord Sudely, F.R.S., the Earl of Crawford and Balcarres, F.R.S., Mr. Charles Cochrane, M.I.M.E., Mr. William Anderson, M.I.C.E., Prof. W. N. Shaw, M.A., Mr. Ludwig Mond, F.C.S., Mr. R. Brudenell Carter, F.R.C.S., Mr. George Berkeley, M.I.C.E., Mr. T. H. Blakesley, M.A., Mr. Jacob Brett, Mr. H. J. Chaney, Mr. Charles Hawkesley, Prof. Huntingdon.

Severe Test to Underground Mains.—A curious accident happened last Sunday at West Brompton which might have caused considerable damage but for the excellent insulation of the House-to-House Company's mains. At about 3 a.m. the West Middlesex Water Works Company's main pipe, 5in. in diameter, in which the water is at a pressure of 125lbs., burst in Barkstone-gardens. The quantity of water that escaped was so great that it inundated the road and caused the ground to sink considerably. The water-pipe was laid 3ft. 6in. below the road level, and the House-to-House Company's electric light mains were about 2ft. 6in. above this pipe. One of their road boxes was exactly over the spot where the pipe burst, and as a large quantity of soil was washed away this box was lowered some 18in. The pipes followed the box, yielding only at the cork joints, and without a single breakage of the wires. The pipes filled with water, which travelled along and trickled into the basements of one of the houses the company are lighting; but, nevertheless, the cable continued to run the lights satisfactorily. This may be considered as a very severe test for any underground system of electric lighting to withstand. Indeed, the gas fared worse than electric light, for a lamp-post 10 yards distant fell down with a crash under the exceptional sinking of the road. Twelve cartloads of gravel had to be put on in order to bring the road to its proper level. The electric mains were raised to their proper position, without the slightest interruption to the working, within 24 hours of hearing of the accident that had occurred. The copper mains of the House-to-House Company's system are very highly insulated, and this fact stood them in good stead. Such an accident is exceptional, but had it occurred in a system employing bare copper wires underground, the result could hardly have failed to be a complete breakdown.

The Barking-road Tramway. — Major-General Hutchinson and Captain Cardew last Saturday visited the Barking-road line of the North Metropolitan Tramways to inspect the new accumulator cars of the Electric Traction Company, and to test their working. After an exhaustive trial these gentlemen expressed themselves thoroughly satisfied with the running and the manner in which the arrangements have been carried out, and a Board of Trade license will no doubt be shortly granted. There are now six new cars ready at the tramcar station for this line, besides the trial car, which we fully described some time ago (September 28, 1888). The six cars are every bit as well furnished as this one, and are furnished with sundry slight improvements upon the first car, one, for instance, being that they are fitted with garden seats on the roof instead of the longitudinal ones which were shown in our illustration. The car-house at the depot is simply filled with storage batteries on long benches. There are six trays of four double cells for both sides of each car, making 96 cells per car. There are six cars, and double sets of accumulators to each car, making over a thousand cells in all. The spray from charging all these cells together will, we fear, cause some trouble to the fittings of the cars unless careful attention is given to the ventilation. Two semi-portable engines capable of indicating up to 120 h.p. each are now erected; and one Immisch dynamo, giving about 115 amperes and 230 volts, is used for charging. A similar dynamo will probably be added shortly, as the whole of the plant will be in duplicate for safety in running. The cells are charged in series in six separate circuits, and resistances are arranged to secure the equal charging of all circuits. The trays of cells make their own connections by springs on being taken out of the cases and slipt upon the benches, fitted with metal pieces, which are arranged on each side of the car track in the depot. The whole of the cars have been carefully tested, and are ready to begin proper running at once. It is expected that one or two of the cars will be run among the horse cars at first, till the drivers get accustomed to the new method of working.

Finsbury Students' Conversazione.—Last Thursday and Friday a conversazione was held at the Finsbury Technical College by the Finsbury students (by the way, not the Old Students' Association, as inadvertently mentioned last week). It was a distinct and undoubted success. The rooms of the college were crowded from basement to chemical laboratory with visitors, students, and their friends, and we are sorry that none of the committee of the college thought well to turn up, as the sight of such activity would have gladdened their eyes. During the evening Prof. Thompson gave a spirited and interesting discourse upon the development of the arc lamp, historically and scientifically, entitled "Arcs and Sparks," which was much appreciated. Music went on in other rooms, and the whole of the college was decorated and fitted with interesting exhibits. The Acme Works were forward with a large exhibit of fittings, switches, fuses, glass, and cut-outs of all descriptions. Messrs. Nalder Bros. had a very fine exhibit of beautitully-finished electrical testing instruments, galvanometers, and voltmeters. The Edison-Swan Company sent some of their lamps and Fleming and Gimingham's ingenious testing instruments. They also showed one of their focus lamps for lanterns, in which the carbon is curled into a very small space for intense light. Messrs. Binswanger and Woodhouse and Rawson sent fittings. Mr. Pitkin

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showed his lamp and Pitkin and Niblett's firedamp detector, Mr. Niblett attending in person. The Brush Company and Paterson and Cooper showed specimens of their apparatus and parts of dynamos. The Bernstein Company lighted the laboratory and showed their series incandescent system. Drake and Gorham had a most interesting set of exhibits of accumulators, fittings, ammeters, etc., and the transformer safety device we mentioned last week. Curious and interesting specimens of metal welding were shown by the Thomson Electric Welding Company. Messrs. Immisch, Statter and Co., and Appleton and Burbey also sent their specialities, and the Planet Engineering Company had an Alpha arc lamp. Besides these, some interesting historical instruments were on view—Hughes' balance and the original apparatus used by Foucault to measure the velocity of light, lent by Mr. Conrad Cooke. It can be seen that the event constituted a fine show, as well as being an interesting social réunion, and we congratulate the Finsbury students on their success.

An Electrically-Driven Gyrostat.—Mr. R. A. Fessenden, writing from Edison's laboratory, New Jersey, to the *Electrical World*, describes a gyrostat in which the motion is obtained from small electric motors fitted directly to the shaft of the revolving parts. One of the peculiar advantages of the electric motor is that it can supply power to a shaft which is itself in no fixed relation to a base, without adding unduly to its weight, or interfering with its motion, and this fact he takes advantage of in constructing a gyrostat which can be given practically continuous motion. The gyrostat has two heavy revolving discs, rotating in opposite directions. On the shaft of each disc is a small motor armature, and the pole-pieces are rigidly attached to the circular frame of the gyrostat. Current is received through the base by very flexible wires. This apparatus affords a means of obtaining very steady motion on board a vessel, or in any similar position. It may be used for taking lunar observations, where greater accuracy is required than with solar observations; also for the photography of eclipses, etc., at sea, and for artificial horizons. The gyrostat may also be used on torpedo boats or dynamite cruisers for sighting the guns. The gyrostat is placed in the conning tower, and the officer in charge sights the shaft, which may be hollow, at the object he wishes the shot to take effect on. Attached to each extremity of the shaft is a rod, so arranged that when the axis of the torpedo tube or gun is parallel to the shaft they complete a circuit, which explodes the charge. The rear rod may be lengthened or shortened to suit any range. The advantage of using the gyrostat is that the officer may take his time to sight the shaft, as the rotation of the gyrostat renders it independent of the motion of the vessel. The idea of using the gyrostat on board ship, says Mr. Fessenden, is not new. Piazzi Smythe observed the transit of Venus with one, but on account of the difficulty in giving it steady motion, it was very complicated and costly. The electrical form of the instrument might be made for less than £20. The *Electrical World*, in commenting upon this, suggests that this continuous gyrostat would solve the difficulty of the mariner's compass, maintaining, as it would, a true north position, independent of the motion of the vessel. If successful, it would possess a distinct advantage over the magnetic needle by not being subject to the variations to which the latter is subject, and in time might supersede the use of the magnetic needle entirely.

The Alexandra Palace Telpher Line.—The new telpher line at the Alexandra Palace promises to be one of the electrical triumphs of the year. Not only will the trains run at two-minute intervals, carrying some 1,000 passengers an hour (the contract stipulates a minimum of 750), but beyond this the gradient is an extraordinarily steep one, especially for a railway running without cogged rails, being not less than one in eleven, considerably steeper than Highgate-hill. The line, which runs from Wood Green Station to the Palace, is nearly half a mile in length—650 yards is the exact length—with a curved terminus at the end to allow the trains to return without detaching the locomotives. The line is a rigid one, consisting of two rails, the up and down lines, carried about 25ft. above the ground, on rows of stout double posts strongly bolted and braced together These posts carry transverse pieces at the top, furnished with iron plates, to which the rails are bolted. The rails are heavy ordinary rails with heads or rolling surface of circular section. The train is to consist of five carriages, and each of these to hold five persons, slung like a long garden seat, with its back to the posts, boxed in somewhat like a cab for five would be, and properly guarded at its ends and in front. The locomotive weighs, with the driver, about 21cwt. The driver sits on top as he would on a tramcar, and controls the switches and the automatic break; the passengers, of course, will hang down below the line, but still, at some distance above the ground, carried along amongst the tree-tops. The locomotive is capable of exerting 15 h.p., and draws the weight of five tons at six miles an hour. The difficulty chiefly to be encountered was that of obtaining sufficient frictional contact for the steep gradient. The ordinary rolling friction of locomotives can be taken as about 350lb. per ton. This, when the locomotive only weighs a little over one ton, would not be enough, and the system of wedge contact has been employed, as equally effective and not so expensive as the ratchet gearing often employed for steep railways. In this system, the circular head of the rail fits fairly tightly into the grooves of the driving wheel, which are tapered at an angle of 60deg. This is found to give a grip of 1,000lb. per ton weight of the locomotive. The Alexandra Palace is taking on a new lease of activity under the organising management of Mr. Lee Bapty, of Manchester and Glasgow exhibition fame, and the aerial telpher line, the first electric overhead passenger railway in England, will no doubt add greatly to its success, and secure to the telpher company a large share of public notice. The enterprise is being carried out for the Mines and General Telpher Company, of 15, Great George-street, the work is being done by the United Electrical Engineering Company, who are the contractors to the telpher company. It is hoped that the line will be ready to open on Whit Monday, in which case the whole work will be carried out within five weeks. This could only have been done by reason of the complete organisation of manufacture of the different parts by the United Co. and the companies working in conjunction with them. The building of the telpher locomotives, the dynamo, and the engines has been carried out by Statter and Co., at West Drayton, the switches, fittings, and small gear at the United Company's Jablochkoff works on the Albert Embankment, and the boiler being the only machinery having to be obtained outside. The present contract for the line is for three years, and the prices for passengers are to be 2d. for the up journey and 1d. for the down

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WHAT IS THE CASH VALUE OF AN INVENTION?

BY SYDNEY F. WALKER.

Few problems are apparently more intricate than this. Every inventor naturally places a high value upon the child of his own brain; and there is a feeling generally prevalent that what an invention does or will fetch is dependent on something very like caprice. And so it is in a great many cases, because, too often, the purchaser of an invention does not intend to work it; he has merely taken it up as a speculation, hoping by its means to extract from others a handsome remuneration for the temporary use of his or someone else's capital.

In a great many cases, however, it should be possible to arrive at an estimate sufficiently accurate for business purposes.

Inventions may be broadly divided into two classes. Those which consist of improvements in apparatus already in use, and those which bring into being for the first time entirely new apparatus, supplying new requirements, sometimes even to be themselves created by the advent of the invention.

The vast majority of inventions belong to the former class. Only epoch-marking inventions, such as the telephone, the incandescent lamp, and the phonograph, belong to the latter.

The principles governing the calculation are the same in each case, but the method of procedure is necessarily different, since the data available in the latter case are not so full as in the former.

The value of any invention, either to seller or buyer, is clearly the difference between two sums—viz., what profit is obtained from the sale or hire of the apparatus directly due to the use of the invention, and what money has to be expended in producing the apparatus and inducing business.

To take a somewhat common instance in electrical engineering, an improved form of dynamo, or an improvement in the construction of dynamos, of what value is it to a dynamo-maker?

First, the manufacturer must ascertain what he is to gain by the use of the invention. To be of any value at all, it must bring profit in one of three ways, either by lessening the cost of construction, by increasing the price obtainable without increasing the cost, or in a greater degree by increasing the business done.

Supposing that a dynamo-maker sells £5,000 worth of machines in a year, and that the invention offered him would enable him, either in reduced cost, increased price, or increased sales, or all these combined, to clear an additional £1,000 per annum. The next point he has to consider is, for how many years may he expect this, and will later years bring a larger increase? In estimating both the yearly profit to be derived from the invention and that of the increased profit in later years, a manufacturer will have to distinguish carefully between the natural increase that would accrue to his business, and that actually due to the invention. This, perhaps, is not a very easy matter, but in many cases it can be estimated nearly enough for practical purposes.

Then as to the time. The protection of an invention by patent, if the fees are paid, and if it is not upset by litigation, extends now for 15 years. Will he estimate for the whole period? Certainly not.

First, he must allow a certain period for getting to work. This may be six months, a year, or even two. Patterns have to be made, old stock worked off or converted, the invention made known. During this time the manufacturer will reap little or no benefit from the invention, while he will be expending money on it. Next, he has to consider how soon the invention may be superseded. Something still better may come out which, if he has the opportunity, he will be obliged to take up, or be pushed out of the market. It is possible also that if the invention is successful, some rival maker will discover that something similar was done or patented 50 years before, and he may be obliged to surrender a portion of his profit to save the rest. Or the apparatus may be rendered obsolete merely through the advance of the knowledge of the science.

Probably, therefore, for inventions of the first class, three years of the estimated profits would be a fair average; or, say, £3,000 in the present case.

What has he to put against this? First, the patent fees to at least the seventh year, as he may be obliged to keep them up even after he has ceased to reap much benefit from the invention.

Next, he has the cost of careful tests of new patterns, new designs, new machinery where necessary, and advertisements of the apparatus if he thinks it necessary; also the cost of converting his stock-in-hand, or the amount he may sacrifice if he decides to let it go cheaper, to prepare the way for the new pattern. He must either do this, or the new pattern will be longer coming into profitable play. Further, if he is wise, he must also add something for possible legal expenses in connection with the patent. If he has not actually to defend his patent, he may be put to some expense by either would-be infringers, or other holders of patents who would wish to have the invention he holds declared an infringement of theirs. The balance between the two sides of this account will represent the gross value of the patent. From this sum the buyer has to substract the discount for the one, two, three, and four years of the proportion of the net sum paid. Thus, if from the £3,000, at which the invention is valued, £1,200 has to be taken as detailed above, £1,800 remains the gross value of the patent; but as the £1,800 would only accrue in sums of, say, £600 per annum, the buyer should deduct a discount for two years on £600, the first year's money, assuming that he allows one year for getting to work, three years' discount on a second £600, and four years' on a third £600. The rate of discount will be the interest that the money would produce invested in his business, in other ways, say, in machinery, a branch office, etc. Thus, if his capital returns him 10 per cent. all round, he will deduct £120 + £180 + £240 = £560, leaving £1,260. If he pays this sum, assuming the estimate to be fairly correct, he will stand, at the end of the four years, exactly where he would have stood if he had not taken up the invention. Therefore, he will probably strike off a further hundred or two or more, according to his ideas, to pay him for his trouble and risk; and this reduced sum will represent to him the cash value of the invention. Of course, if instead of doing £5,000 per annum, the manufacturer had been doing £100,000, the invention should be worth to him at least 20 times as much, though it must be borne in mind that the cost of patterns, alterations, advertising, and litigation will also be very largely increased.

THE EXETER ELECTRIC LIGHT COMPANY'S CENTRAL STATION.

The Exeter Electric Light Company, Limited, having purchased a site in the New North-road, most suitable for the purpose, near the centre of the city, is now fitting up a central station for supplying electricity to hotels, shops, public buildings, and dwelling-houses. At first only the main business portions of the city will be supplied, but later it is hoped to carry the lines into the suburbs.

Permission for overhead wires having been obtained from the City Council, the mains will be supported on ornamental iron posts, erected in a line with the kerbstone on either side of the street. The Thomson-Houston system of arc lighting and the Mordey transformer system of incandescent lighting will be used. Current will be supplied at a definite price per lamp per annum, a charge of 10s. being made for each 10-c.p. incandescent lamp, the consumer to pay for lamp renewals. Arc lamps will be supplied at various prices, according to the hours during which the lights are used, the lowest price being £9 and the highest £13 per 1,200-c.p. lamp per annum.

The whole of the plant at the central station will be in duplicate, and will consist of two 105 h.p. Babcock and Wilcox boilers, working at 140lb. pressure, supplying steam to two compound horizontal engines by Messrs. Fowler and Co., Leeds, the engines each giving 125 brake h.p. at 90 revolutions per minute. The low-pressure cylinders are 24in. diameter, high-pressure cylinder 13in. diameter and 24in. stroke, flywheel 12ft. diameter. Two triple expansion Westinghouse engines by Messrs. Alley and Maclellan,

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Glasgow, each engine giving 20 brake h.p. at 400 revolutions per minute.

The dynamos are two 75-unit Mordey alternators, with Victoria exciters coupled on to shaft, each machine being driven direct from the flywheel of the Fowler engine by means of eight ropes; speed 200 revolutions per minute, pressure 2,000 volts. Two 30-light Thomson-Houston machines, each belted direct on to a Westinghouse engine; speed 900 revolutions per minute, current 6·8 amperes.

The switchboard will be so arranged that, in the event of a dynamo or engine breaking down, the whole load may be instantly thrown on to the spare dynamo and engine. It is expected that the station will be completed early in July, when the supply of current will commence. At first the hours of lighting will be from one hour before dusk until 12 p.m. each night.

Contracts have already been obtained for lighting some of the principal hotels, and many of the leading shops and business premises.

The new theatre which is now being built is to be lighted by electricity, and it is hoped that the local company will get the contract for carrying out the installation; tenders for doing the work have been sent in.

It is probable that several churches will shortly be provided with the electric light. Altogether, the Exeter Electric Light Company has every prospect of doing a large amount of work, and there being plenty of space in the central station, additional plant will be put down as the demand increases.

ON THE SECURITY AGAINST DISTURBANCE OF SHIPS' COMPASSES BY ELECTRIC LIGHTING APPLIANCES.*

BY SIR WILLIAM THOMSON, D.C.L., F.R.SS. (L. AND E.), PRESIDENT.

The danger to be avoided is sufficiently explained in the following short statement by Mr. William Bottomley, which appeared in the *Nautical Magazine* for December, 1885:

"The following example of a case which might occur in any large ship will show the amount of error which may be produced on the compass" [by the electric lighting apparatus] "unless precautions are taken to guard against it.

"Suppose a main lead from the engine-room to the fore part of the ship, to light up 100 lamps, is brought along the centre of the ship. It may be at a distance of 10 metres, or 33ft., from the standard compass, and will run almost underneath it. If we suppose that each lamp takes one ampere of current, there will be a current of 100 amperes altogether in this lead. Now, the effect" [of an infinitely long straight current] "on the compass" [above it] "at a distance D in centimetres is given by the formula

$$F = \frac{2 \times \frac{1}{10} C}{H D},$$

where C is the current in amperes and H is the horizontal magnetic force. In this case we have C = 100 amperes and D = 1,000 centimetres. Therefore,

$$F = \frac{20}{1{,}000\,H} = \frac{0{\cdot}02}{H}.$$

At Glasgow the horizontal force may be taken as 0·15 in C.G.S. units; therefore the effect on the compass will be $\frac{\cdot 02}{\cdot 15} = \frac{1}{7{\cdot}5}$. This will be expressed in degrees by multiplying by 57·3 the number of degrees in the radian, or angle subtended at the centre of a circle by an arc equal in length to the radius. Therefore, the amount of error produced by such a current on the compass will be $\frac{57{\cdot}3}{7{\cdot}5} = 7{\cdot}6$ degrees.

"The foregoing refers to a single wire and a continuous-current machine; but if an alternate-current machine is employed, no effect will be produced on the compass, even when the ship's side is used for the return. When a continuous-current machine is used, the danger of producing an error on the compass can be avoided by using two wires close to one another, but these wires should be well insulated from the ship's side. If in any way" [two points of] "one of the wires is brought in contact with the iron of the ship, there may be no change observable in the lighting, but the current may produce as much error on the compass as it would if there was only a single wire.

"The following points should therefore be attended to in all cases of lighting ships by electricity: First.—With continuous-current machines two wires, well insulated, should always be employed. Second.—The insulation of the wires should be tested periodically; if any connection with the iron of the ship is found, the fault should at once be made right. Third.—When an alternate-current machine is used, a single wire may be employed, and the iron of the ship used to complete the current without producing any effect on the compass.

"What makes this question of the greatest importance is that the error may be produced without ever being detected by the officers of the ship. On board ship the errors of the compass are usually determined during the day, in the morning and afternoon, but the electric light is only used at night. The captain may therefore carefully determine his errors every day, and set his course quite correctly; but at night, when the electric light is turned on, the ship may be going several degrees off her proper course, although she is being correctly steered by the compass.

"In connection with the lighting of ships with electricity, there is another point which should also be attended to—that is, the position of the dynamo. If it is placed near an iron bulkhead, the upper end of which is near the compass, the bulkhead may become magnetised by induction so powerfully that it will produce a considerable error on the compass."

The subject was also referred to in Mr. Bottomley's paper on "The Magnetism of Ships and the Mariner's Compass," read before the Society of Arts, January 28, 1886, and published in the *Journal* of the Society for February 5, 1886. In the discussion which followed, and in which Captain Creak, of the Admiralty Compass Department, Mr. Alexander Siemens, and Dr. Hopkinson took part, it appeared that in three ships lighted on the single-wire system with direct currents, small but not unimportant errors in the compass, due to the lighting currents, had been actually observed. Since that time several cases have been reported to me of large passenger ships, lighted with direct currents on the one-wire system, in which as much as 4deg. or 5deg. of error on the compass has been produced by the electric lighting. In the latest of these cases, a few weeks ago, an error of 4deg. on the north course was found when the light was put on. The light was put on and off several times with the ship's head north, and every time the same error was produced.

The precautions for security which I have to suggest are—

1. The use of the two-wire method exclusively (unless, which is now rarely the case, alternate currents are used).

2. A differential galvanometer on the two mains for the lighting current to show approximate enough equality of the outgoing and incoming current. A rough and cheap instrument (on the old telegraph "detector" plan) would, I believe, suffice, and would be valuable for the electric lighting system (independently of the compass question) to give timely warning of any faults or accidental contacts or failures of insulation sufficient to cause any considerable difference in the strength of the currents carried by the two mains.

3. Care that there is not magnetic "leakage" from the dynamo (as practical men, guided by Faraday's ideas, theory and language, have now taught the scientific world to call it) enough to produce any compass disturbance of practical moment. Capt. Creak, speaking at the end of 1885, in the Society of Arts discussion previously referred to, said that in one ship the direct compass-disturbance produced by the generating machine was "felt through a distance of 55ft.," and across iron bulkheads, and that it

* Paper read before the Institution of Electrical Engineers, May 23.

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was perceptible also in other ships of the Royal Navy electrically lighted on the two-wire system. My impression is that the improved dynamos now made have much less of magnetic leakage than those made prior to 1886, but we still want information as to their disturbing magnetic effect at such distances as have to be considered in connection with the compass question.

4. To ascertain that there is no perceptible compass-disturbance, or if there is any to test its amount, the compass should be observed while the current through the dynamo is started and stopped, either by starting and stopping the dynamo itself, or by making and breaking the circuit of the field-magnets. This should always be done before the electric light installation is taken over from the contractors. It is best and most easily done when the ship is in dock, or lying steadily at anchor. On no account ought it to be delayed, in a new ship, till she goes out for compass adjustment. A determination of the amounts of the disturbance (if any) for all courses of the ship can be made by aid of my deflector without moving the ship. But a sufficient practical test may be made by first observing the effect of starting and stopping the current, on the compass as it stands; then adjusting a small magnet placed on, or supported a little above, the glass of the bowl, to deflect the compass about 45deg. first on one side and then on the other side of its undisturbed position, and in each case observing the effect of starting and stopping the electric current. This effect ought not to be as much as 2deg. in any of the three cases.

5. A small electric lamp may safely (and with very great advantage in most cases of electrically lighted ships*) be used to light the compass. The effect, if any perceptible, of its current on the compass ought to be tested in the manner described in No. 4.

Discussion.

In opening the discussion, **Capt. Creak** said he was glad Sir William recommended the two-wire system, for that in itself was a great safeguard against disturbance. So far as his own experience went, most trouble arose from magnetic leakage due to the employment of machines having considerable external field, and placing them in positions with respect to the iron of the ship that such field was directed towards the compass. In one case (H.M.S. "Northampton") where three such machines were used, an error of 11deg. was produced when all the machines were running, and three correction tables were necessary.

Mr. Alex. Siemens, as an advocate of the single-wire system, thought it quite unnecessary to use two wires, for in all his experience, extending over many ships fitted on the single-wire system, only one instance had occurred in which complaint was made, and in this case the wiring was done before the position of the compass had been decided upon, the spot eventually chosen being in close proximity to the leads. As a proof that the single wire system could be made satisfactory, he mentioned that his firm make enquiries on all vessels fitted by them every time they came into port, in order to ascertain whether any inconvenience arises from the electric lighting apparatus, but with the exception above quoted no complaint has been made. Referring to Mr. Bottomley's letter mentioned in the paper, Mr. Siemens said the screening effect of the decks had been entirely neglected in the calculations there given. A second case of disturbance had come under his notice by his being asked to inspect a ship fitted by another firm, and the maximum deflections produced were ½deg. and 1½deg. on the standard and steering compasses respectively. As regards the position of dynamos, he had found no appreciable effect at distances greater than 50ft.

Prof. G. Forbes, speaking of H.M.S. "Northampton," said that the dynamos referred to by Captain Creak were placed in an iron room, and still the disturbance produced was very serious. From an examination of machines of the type there employed, he found that the leakage mainly comes from the parts of the yokes near their junction with the cores; but he had reason to believe that in the more modern machines the leakage has been considerably reduced.

Prof. Jamieson mentioned the case of the ss. "Bombay," in which the steering compass was disturbed 9deg. The fault was traced to a wire about 4ft. from the compass, and remedied by running a return wire.

Mr. Raworth, in corroborating Mr. Siemens with regard to the great convenience of the single-wire system, gave additional details respecting the second case mentioned by Mr. Siemens. The compass was influenced by either of two conveying wires running along lower passages, according as the needle was parallel to one or to the other. On examining the decks, the iron was found cut away between the wires and the needle, and the defect was remedied by enclosing the former in 3in. iron pipes.

Major Cardew described his experience in lighting binnacles electrically as suggested by Sir W. Thomson in his note, and although he carefully twisted the leading wires together the filament seriously affected the compass and readings.

Sir W. Thomson, in reply, said that caution was necessary in arranging lamps for lighting compasses, and in answer to Prof. Forbes, expressed an opinion that alternate currents if used in such lamps would not demagnetise the needles. Referring to the screening effect of decks, he pointed out that Captain Creak's observations proved them to be of little use in neutralising the external field of dynamos, and to be efficient the iron required to be very thick. The decks may, however, considerably reduce the action of currents on the compasses, especially where the circuits are completed between two decks, but when the wires pass from one deck to another, the screening effect is much reduced. Although the conductors in the single-wire-system may be placed so as not to affect either one of the two compasses generally used, yet it is very difficult to arrange that neither are disturbed, and as any disagreement between the two (especially as the difference may vary with the portion of the ship being lighted) further complicates the navigation, Sir William felt sure it would be far the best plan to adopt the two-wire system in all cases.

The discussion on Mr. Mordey's paper on "Alternate Current Working" was deferred till the next meeting on May 30.

* Those who know the trouble of keeping the best of ordinary compass lamps alight, for the steering compass on the bridge of some of our cross-Channel steamers in a winter gate, will appreciate this advantage.

THE EFFICIENCY OF METHODS OF ARTIFICIAL ILLUMINATION.*

BY EDWARD L. NICHOLS, PROF. OF PHYSICS IN CORNELL UNIVERSITY.

(Continued from page 378.)

The spectrum of rays reflected from the face of the magnesium carbonate, however, contains in proper proportions the light from all portions of the source, and one of the chief sources of error to which spectro-photometric work is subject is thus eliminated.

The investigations made with this instrument, which have been described in a paper read before the American Association,† included the measurement of candle flames, and of various petroleum and gas lamps, also of the limelight, the incandescent lamp under a wide range of conditions, of the electric arc, and of daylight by clear and by clouded sky. The results obtained illustrate the precise character of those differences in composition to the bearing of which, upon the study of the efficiency of artificial illumination, I desire to call your attention.

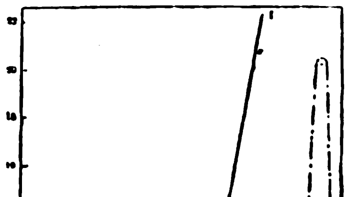

Fig. 8.

In the first place, it was found that the light of the candle, and of oil and gas flames, although subject to considerable fluctuations from variations of the condition under which combustion occurs, but differ slightly in quality from each other and from that of incandescent lamps maintained at normal candle-power. The incandescence material in all is carbon, and it is a significant fact that the average temperature of incandescence is nearly the same in all luminous flames, and that the

* Paper read before the American Institute of Electrical Engineers, March 12, 1889.

† Edward L. Nichols and W. S. Franklin. "A Spectro-Photometric Comparison of Artificial Sources of Illumination." Paper read before Section B., A. A. A. S., at the Cleveland meeting, August, 1888.

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highest temperature, until very recently at any rate, at which it has been found practicable to maintain the carbon filament of the glow lamp, is very nearly that at which the same material exists under the most favourable conditions in oil and gas flames. Hence it is that the radiant energy per candle-power, as has been shown by Julius Thomsen, is nearly the same for all these flames.

Passing to other sources of illumination, such as the lime light and the electric arc, we find the entire portion of the spectrum lying beyond the yellow increasing more rapidly, regions of longer wave-length than the yellow increasing less rapidly than the candle-power, the rate of increase growing steadily as the wave-length diminishes from the red to the violet end of the spectrum. Fig. 8 shows the results of comparisons of the spectra of the lime light, electric arc, and of daylight, by clear and by unclouded sky, with that of an incandescent lamp maintained at its normal candle-power. This lamp, which was chosen as a standard of comparison, was an Edison 16-candle, 100-volt lamp. Its light was precisely similar to that of a "Board of Trade" argand gas-burner, showing the same relative brilliancy throughout the whole of the visible spectrum. The measurements were made with the spectro-photometer just described (see Fig. 10), the light in every case falling upon the block of magnesium carbonate, and entering the slit of the spectroscope after reflection from the face of the latter. For purpose of comparison, the brightness of the standard incandescent lamp has been taken as unity throughout the spectrum. If we make a diagram in which abcissæ are wave-lengths and ordinates, intensities, referred

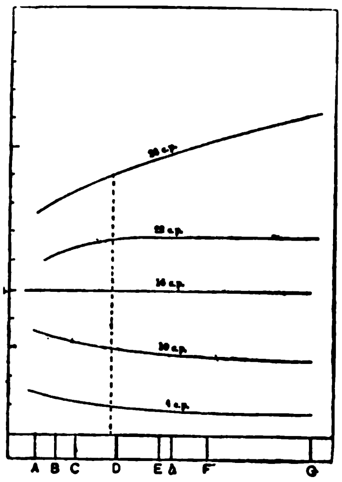

Fig. 9.

to that of the standard as unity, the curve for this lamp will be a straight horizontal line, with ordinate = 1.

All other spectra are reduced to the same brightness in the region of the D line of Fraunhofer, and their brightness in other regions, referred to that of the corresponding wave-length in the spectrum of the standard, is shown by means of curves.

Observations were made in 10 regions of the spectrum, equi-distant as to wave-length, and embracing the whole of the visible spectrum. It will be seen by reference to the figure that the lime light is relatively much stronger in the violet, and much weaker in the red than the standard. In the arc light this increase of intensity toward the violet is even more marked, but its variation in quality from the lime light is by no means so great, as its exceedingly brilliant, bluish-white appearance to the eye would lead us to expect. The source of that appearance and of the very high actinic value of the arc is found, however, in the presence of an exceedingly bright band in the extreme violet. Here the relative intensity of the arc light spectrum rises abruptly about three to 20 times that of the incandescent lamp.

Measurements were made upon a long arc lamp with ½in. carbons, with 10 amperes and 50 volts, and a short arc lamp with a 20-ampere current. The character of the light was found to be almost identical excepting in this light band in the neighbourhood of the G line, which is much more prominent in the long arc lamp. The character of the light was found to be much the same at all angles below the horizontal plane.

The only other spectro-photometric measurements of the electric arc with which I am acquainted, have been made upon the Foucault regulator, a lamp with carbons of small diameter. Fairly concordant determinations of the distribution of intensities in the spectrum of this lamp by W. H. Pickering*, H. C. Vogel†, and Crova‡ show that the light of this lamp is decidedly bluer than that of the lamps with large carbons in vogue at the present day, the spectrum of the former being about five times as rich in the violet as that of gas or oil flames. Mr. Nakano's results, of which mention has already been made, indicate marked increase in the efficiency of the arc lamp as the diameter of the carbons is decreased; and since increase of efficiency arises from a higher average degree of incandescence, we should expect just such an increment in the shorter wave-lengths as shows itself in the case of the Foucault regulator.

Finally, in the case of daylight, we find the intensity of the shorter wave-lengths exceedingly great as compared with that of any artificial source of illumination. If the spectrum of daylight be brought into comparison with that of an incandescent lamp, and the two be reduced to the same intensity in the yellow, the extreme red of the daylight spectrum will be so dim in comparison with that of the lamp, as to render measurements difficult. In the violet the discrepancy will be just as marked, the sun's spectrum being relatively of enormous brilliancy. Curve I., Fig. 8, shows the result of such a measurement of the daylight spectrum, taken just after noon upon a cloudless summer day.

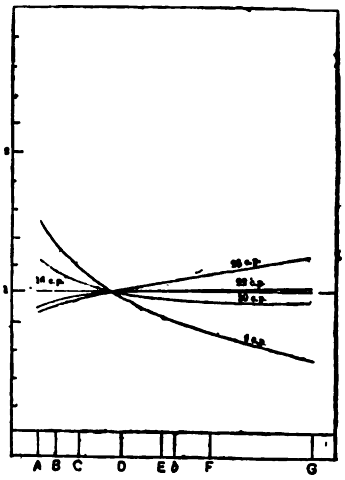

Fig. 10.

Vogel has given data of a determination in which the preponderance in the violet was even more marked, the relative intensity of daylight for the region corresponding to wave-length 4,260 (just beyond the G line), being 100:1 for spectra, which were equally bright in the neighbourhood of the D line.

Ordinarily, there is considerable absorption of the blue and violet by moisture in the atmosphere, and a measurement of daylight under a densely-clouded sky gave curve II. Even under these conditions, with the violet reduced to about one-tenth of the value which it possesses in clear weather, daylight is very much bluer than any artificial light. The light emitted by burning magnesium approaches more nearly to it than any other, being, according to Pickering, considerably stronger throughout the blue and violet than the light from the Foucault arc lamp. Its colour, however, is not reinforced by a violet band like that in the spectrum of the electric arc, a region which by its extraordinary brightness has marked influence upon the colour of the light.

These variations depend upon temperature primarily, and they may be studied to the best advantage in the spectrum of the incandescent lamp. The radiating surface of such a lamp is at a nearly constant temperature through out, and it may be given a very considerable range in the matter of incandescence, involving variations in colour and total intensity, which are under complete control.

(To be continued.)

*W. H. Pickering, *l.c.* †H. C. Vogel, *l.c.* ‡A. Crova, *.c.*

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THE

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IMPORTANT NOTICE.

Although the Paris Exhibition is open, the major portion of the exhibits are in so backward a state that any systematic description is almost impossible at present, so we shall wait a short time till the chaos of packing cases becomes a neat arrangement of exhibits. It is needless to tell our readers that—so far as our description of the electrical exhibits is concerned—our attention will, in the first place, be directed to the interests of English and American exhibitors. A special edition of this paper, with the report of the exhibition in two languages—English and French—will be obtainable in the Exhibition.

SHIP LIGHTING.

The paper or note of Sir Wm. Thomson read and discussed at the Institution of Electrical Engineers last week brought forward one of the most important practical questions that the electric light engineer has to deal with. The result of the discussion was somewhat unsatisfactory, inasmuch as the differences of opinion were not absolutely settled. The problem is a simple one and can be presented without verboseness. It is admitted on all hands—that is, by the opponents as well as the advocates of general electric lighting—that this kind of lighting is admirably adapted for use on board ship. So far as we know, assuming no danger of breakdown in the apparatus used, the only real objection ever urged against the use of electric light on board ship has been the possibility of unrecognised action upon the compasses leading to disaster. If all possible errors of the compass are known, it is not difficult to make the necessary corrections and to steer correctly. A pure landsman never can recognise, and, in fact never does recognise, the absolute necessity of knowing all about his compass to a sailor. He begins to recognise the real value of this knowledge when on board ship, off a dangerous coast in a thick fog. The lives of all on board and the safety of the ship then depends solely on the correct knowledge of the compass errors. The introduction of any magnetic action, or action from electric currents, as is the case in the use of electric lighting apparatus, brings influences into play which affect the compasses, the action upon which, therefore, should be fully known. It is usual to consider two sources from which the compasses may be affected—the currents traversing the wires of the circuits or lamps, and the straying lines of magnetic force which, like individuals of a romantic turn of mind, often go where they ought not to go. With regard to the latter, as our knowledge of the proper construction of dynamos increases, and if the mechanical construction is carried out in accordance with this knowledge, the wandering lines decrease, and, at any rate, the difficulties arising from this source are easier compensated than the other. The greatest attention, therefore, has been paid to the action of the currents in the wires, and two schools of practicians have arisen, the one advocating a double-wire system, the other a single-wire system. The former may be dubbed the theoretical practicians, who are more theoretic than practical, while the latter are almost wholly of the practical. The advocates of the single-wire system contend that experience shows perfect safety when the work is properly done, and the perfect practicability of screening the compasses from evil effects of the current. The theorists say the screens will not act. The practical men laugh at theory and point out the actual fact that the iron tube does screen, hinting that theory

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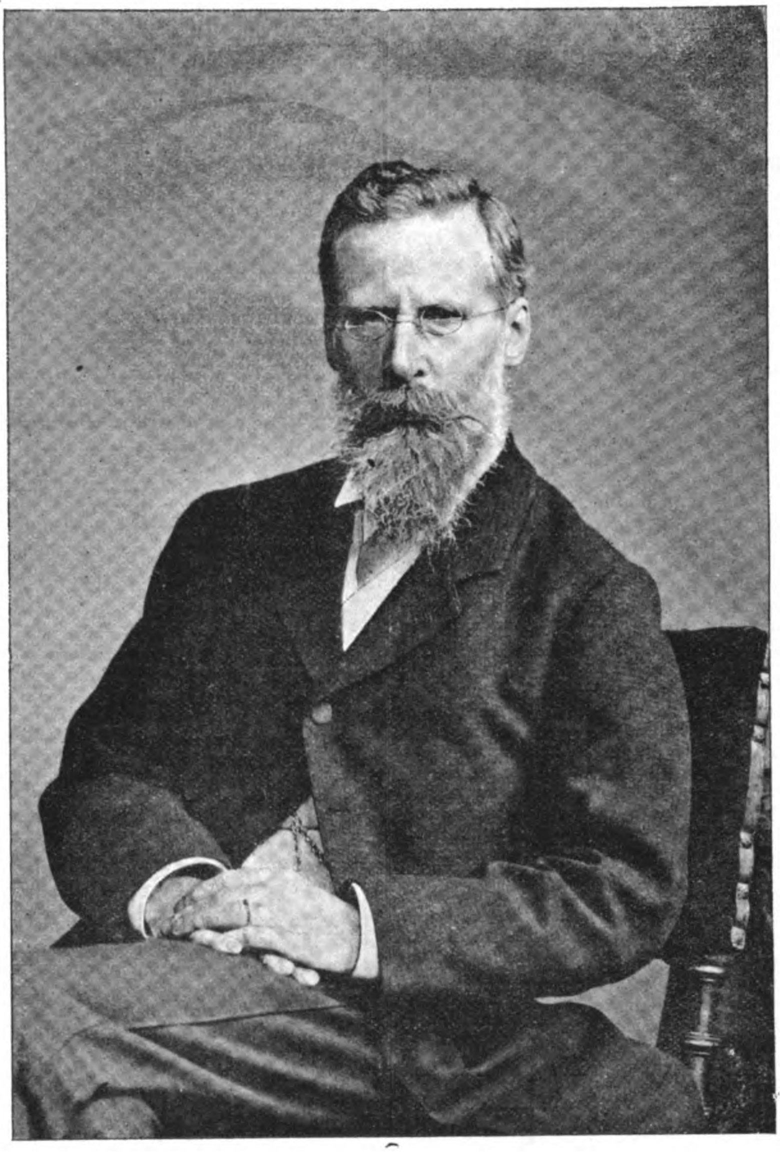
may be wrong, while the facts remain facts. To the outside world the discussion of the question remains in the state we have mentioned, two sides, two systems, not in accord; but as to the future we may safely predict the two-wire system a thing of the past, that most of the work now done is on the one-wire system, and this kind of work will increase till its rival has no place in ship lighting. This conclusion is directly opposite to the first suggestion of Sir William Thomson, that where continuous currents are used "two wires well insulated should always be employed."

We are glad that Sir William Thomson has again called attention to the possibility of errors being overlooked because the errors of the compass are usually determined during the day, when the electrical apparatus is not in use. To ascertain the compass disturbance is a simple matter. Sir William says, "a sufficient practical test may be made by first observing the effect of starting and stopping the current on the compass as it stands, then adjusting a small magnet placed on, or supported a little above, the glass of the bowl, to deflect the compass about 45deg. first on one side and then on the other side of its undisturbed position, and in each case observing the effect of starting and stopping the electric current. This effect ought not to be as much as 2deg. in any of the three cases."



WILLIAM CROOKES, F.R.S.

THE ELECTRIC COMBINATION.

Rumours have come to our ears for some time back with reference to the immense electric combination, negotiations about which have been quietly proceeding, but nothing very definite could be said. Now, however, that the affair will probably be out and put before the public within a very short period, some more exact idea of what is pending may perhaps be given. The undoubted success of Sprague in America, and of the proved satisfactory nature of accumulator traction for tramways at Birmingham, has aroused the tramway companies and the manufacturers who supply them to a keen sense of the probable direction of future work in suburban traffic in England; and to safeguard these interests, as well as to unite in a common aim some of the leading men in electrical engineering, both to avoid competition and from a financial point of view, is, we may take it, the idea of the combination. The firms who will probably join in the combination are the Electrical Power Storage Company, Elwell-Parker, Limited, the Sprague Company, the Julien Company, Hammond and Co. (the House-to-House Co.), the Falcon Engine and Car Works, and some of the large tramway companies are also mentioned. The title of this gigantic company, as far as has been settled up to the present, will be the Electric Works Construction and Maintenance Company. This title has already been registered as the Construction Department of the House-to-House Company, and will be taken over together with that part of the business of the House-to-House Company. The main work of the company is intended to be the construction of electric plant and machinery, and the carrying on of electric traction work, both for tramways and also for heavier electric railways. It is also intended to establish central stations in the provinces for distribution of light and power. The financial part of the undertaking is, as can be imagined, the most serious part of the negotiations, and a very large capital will

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be required. It is understood that the shares in the E. P. S. Company will be bought up at par value, and the shareholders at their discretion can have the whole value of their money returned. The tendency to these gigantic combinations is evidently taking deep root in English soil, and the result of the movement, whichever way it proceed, will undoubtedly have a very large effect upon the electrical engineering profession.

W. CROOKES, F.R.S.

William Crookes is another of our vice-presidents whose presence confers honour upon the Institution of Electrical Engineers. He has long made his mark, and attained the blue ribbon of science (the Fellowship of the Royal Society) from his chemical and physical researches. Of late years he has paid great attention and given deep study to the subject of molecular physics. His *confrères* in the chemical world have paid him the honour of electing him President of the Chemical Society, a society that ranks almost, if not quite, on an equality with the Royal in the estimation of its members.

Mr. Crookes is a Londoner, born in 1832, entering the Royal College of Chemistry in 1848 as a pupil of Dr. Hofman, whose little book on chemistry should be carefully read by every electro-chemist and electro-metallurgist. In 1849 Mr. Crookes gained the Ashburton scholarship, and next year became junior assistant to Prof. Hofman, subsequently becoming senior assistant, which position he retained till 1854, when he obtained the appointment of superintendent of the meteorological department of the Radcliffe College, Oxford. The list of papers on scientific subjects that Mr. Crookes has contributed to the various societies or to periodical literature is a lengthy one, and the investigations described therein are mostly of a practical character. Mr. Crookes is the author or translator of several works on chemical and metallurgical subjects. It will be seen that he must of necessity be fully cognisant of the chemical literature and progress of the last quarter of a century when it is stated that in 1859 he founded *The Chemical News*, and that he is still the editor and proprietor of that paper. The introduction of incandescent lamps, perhaps, brought Mr. Crookes's name prominently before electricians, because the value of these lamps depends largely upon the perfection of the vacuum, and his investigations upon "Molecular Physics in High Vacua," published in the Royal Society's *Transactions*, came just at the time when men's minds were exercised on the question. Another interesting paper at this period was in the form of a lecture delivered before the British Association, when, under the title of "Radiant Matter," he gave a *résumé* of his investigations on electric discharge in high vacua. In 1880, the French *Académie des Sciences* bestowed on Mr. Crookes an extraordinary prize of 3,000f. and a gold medal, in recognition of these discoveries in molecular physics and radiant matter. Two years since, Mr. Crookes was president of the Chemical Section of the British Association, and in his address he struck another note, contending from reason and experiment that the so-called chemical elements are really compound bodies, and his presidental address to the Chemical Society was a continuation of this subject.

GASTON PLANTE.

We regret to chronicle the death, at Paris, of M. Gaston Planté, whose name has been familiar to electricians for many years past. To M. Planté, in a great measure, is due the development of accumulators. His experiments with lead, and the results obtained therewith, led others, notably in the first instance M. Faure, to attempt something giving greater perfection with less loss of time. M. Planté was at one time chemist to the firm of Christofle et Cie., the well-known electro-metallurgists, and his work there led him to study the phenomenon of polarisation, and to the construction of his well-known type of secondary battery. It has always seemed to us that M. Planté approaches somewhat to the type of the ideal man of science. He was more at home in his laboratory than amid the whirl of the busy world, and for the most part was content to live a very retired life. Many of our readers have, however, from time to time met M. Planté either during the bustle of exhibitions or in the quieter social life, where at all times they would find him ready to listen and ready to give from the large fields of his experience. Of late years his health has been exceedingly precarious, and his kindly face will be missed by many who hoped to have had a friendly greeting from him during this exhibition year. He was the author of several books and many pamphlets on his favourite subject, some of which have been translated into English.

Electric Water Indicator. — Mr. G. Jennings, Lambeth, has recently obtained contracts for fitting electrical apparatus for indicating the level of the water in the reservoirs of the water works companies at Weston-super-Mare and at Bristol.

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CORRESPONDENCE.

FIREDAMP DETECTORS AND ELECTRIC MINERS' LAMPS.

To the Editor of The Electrical Engineer.

Sir,—By the tenor of Mr. Sydney F. Walker's letter, I take it that he imagines that the active materials we employ in our detectors are liable, under certain conditions, to become at least red hot. I may say that so far we have not, under any circumstances, attained a higher temperature than 250deg. F.

I am well aware that explosions may be and have been caused by air containing an explosive percentage of gas being caused to pass rapidly through the wire mesh of a so-called safety oil lamp. I imagine that under these circumstances the oil flame partakes of the nature of a blowpipe flame, which, when impinged with violence upon one portion of the protecting gauze, supplies heat to that part with greater rapidity than it can be carried off by conduction and radiation, and it thereby causes the gauze to become sufficiently heated to induce violent combustion in the surrounding air.

As firedamp and air even in their most explosive proportions require a higher temperature than a red heat to cause rapid ignition, I doubt very much whether an accidental breakage of the glass bulb of a good electric glow lamp would induce an explosion even in a very dangerous atmosphere. I now allude to a well-made and thoroughly exhausted glow lamp, such as those now used in the best forms of electric miners' lamps. Those conversant with the manufacture of incandescent electric glow lamps are well aware that a short and thin carbon filament, which, if heated by the current in air will only emit a dull red heat, will give out, with the consumption of the same amount of electrical energy, a brilliant white light when enclosed in a good vacuum. The difference of light is still more marked if hydrogen or some of its compounds are used instead of air. The explanation is, that air and many other gases are good absorbents and conductors of heat, while a vacuum is a very bad conductor. For these reasons I apprehend no danger from the breakage of these small glow lamps in mines. The mass of air, or mixed air and gas, would instantaneously carry off the small amount of heat contained in a carbon filament not more than a quarter of an inch long, and of about the sectional area of a human hair.

I quite agree with Mr. Walker when he states that a gas detector should be placed in the hands of every working collier, not only for the safety of the mine, but from a hygienic point of view. The indicator should give an aural or visual indication, it should be certain in its action, and to be certain it must be simple. To be of real service it ought to be automatic, and, if possible, it should be attached to the lamp. It is with this end in view that we are now working.

There can be but little doubt but that in the not very far and distant future all working in our coal mines will be carried on by aid of the electric light—probably a combination of fixed and portable lamps. In attempting to meet the requirements of miners, many difficulties will have to be overcome. We are asked to supply lamps which shall be:

1. Absolutely safe in an explosive atmosphere.
2. They should give a far better light than any of the oil lamps now in use.
3. The duration of light with one charge must be from eight to ten hours.
4. They should be easily and quickly charged, and should require no skilled labour or attention.
5. They ought not to be too heavy, or clumsy in shape.
6. They should be so constructed that they would safely stand on the roughest ground, and should be capable of being suspended on a hook.
7. They must be made to burn in any position, and should be unspillable.
8. There must be no loose or exposed contacts, and everything should be quite water and dust tight. The light must not be liable to be extinguished by a jerk or any concussion in the air. Again, the materials used in the construction of the lamp should be sufficiently strong to withstand such little freaks of the colliers as using it as a mallet to drive a peg or hook into the coal or wooden support whereon the lamp may ultimately be suspended, or to be used a stool for the miner during his meals. The last-named purposes scarcely enter into the general calculations of the lampmakers, but as I have seen them being used for these purposes, I should think it wise to make the lamp-cases sufficiently strong to withstand such usage.

The position in which the lantern should be placed seems a very vexed question. Many miners insist upon its being placed on one of four sides—say, of a square lamp—so that the light is cast well forward; others say that it would be better to fix it on one corner, thus throwing the light both in front and sideways as well. Again, some suggest placing it on the top so that it would well illuminate the roof, which they look upon as the most fruitful source of danger. Others maintain that the light should be placed at the base of the battery so as to bring it as near as possible in the same position as the oil lamp, because the men have been used to the light in that position.

Lastly, but not least, the lamp should be durable, and cheap, and the cost of supplying the daily requisite amount of electrical energy must be small.

I am aware that Mr. Walker has had some considerable experience in the electric lighting of mines. I should therefore like to get his opinion as to the best position for the lantern on a combined portable battery and lamp.—

Yours, etc., J. T. Niblett.

May 29.

ALTERNATE CURRENT WORKING.*

BY W. M. MORDEY.

(*Continued from page 422.*)

Now, I am prepared to take a precisely similar stand with regard to alternators, and to submit for your criticism the view that a perfect alternator for any and every purpose should have no resistance and no self-induction.

I prefer to regard the question of alternate-current parallel working as a question very largely depending upon what are the best principles of construction for synchronising alternate-current motors. It is very much better and simpler to look at it from this point of view than from any other, and I venture to assert, in spite of all that has been said to the contrary, that if alternators are made, amongst other things, with the least possible self-induction and the lowest practicable resistance, they will not only be the best alternators, but they will best run parallel, and will do so because they will then be the best synchronising motors.

I think that even the advocates of large self-induction will admit that that quality does not improve an alternator *per se*, they only introduce and tolerate it on account of its supposed bearing on parallel working (I could quote a number of such admissions), but it appears to me that, properly regarded, self-induction is not even a necessary evil—it is an unmitigated evil. It is an evil even for this narrow and restricted purpose.

What does it do? When machines are getting out of phase, it steps in and prevents that ready transfer of current which is required in order to check the leading machine, and to accelerate the lagging machine. It prevents the latter from immediately and unhesitatingly developing those motor properties which lie at the root of successful synchronism. The foundation of parallel working should be that the prime motors are under the control of the generators. The question turns, therefore, partly on the qualities of the prime motor, but much more largely on the motor qualities of the alternators.

I am prepared to admit that if the tendency of the prime motor to lead or to lag is so great that under no circumstances can it be controlled—and this may arise either from excessive power on the part of a prime motor, or from defect of motor power in an alternator—then large self-induction or resistance may be of use in order to prevent one or more of the machines being burnt up, not, however, as useful and not as effective as a safety-fuse; but self-induction under such circumstances is not an assistance to parallel working. Quite the contrary. If it were absent, probably the machines would run parallel all right. They would be much less likely to be burnt up without self-induction than with it. Self-induction is useful because it prevents the machine which ought not to have it from being burnt up because it has it.

Now, I will briefly describe some experiments with two of my alternators, each made for 2,000 volts, and each capable of working continuously at 35,000 to 40,000 watts, or, say, 50 e.h.p. output.

Arrangement.—Each machine was driven by 75 i.h.p. Fowler engine. These engines were similar, their normal speed of working being 120 revolutions per minute. Each of the engines, which were

* Paper read before the Institution of Electrical Engineers.

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not coupled or connected in any way, was provided with a heavy fly-wheel, and drove, besides an alternator, a heavy and wasteful double (and in one case treble) set of countershafts provided with a large number of belts, fitted to an arrangement of fast and loose pulleys for convenience of testing all sorts and conditions of dynamos. I mention this as showing that the momentum in each case was very considerable.

In order to make the test as onerous as possible, the pulleys used were such that one engine had to run at 130 revolutions, while the other ran at 90 revolutions, when the alternators were at their normal speed of 650 revolutions per minute.

(1) The alternators were run up to full speed, and each excited to give 2,000 volts. When in phase they were switched parallel without any external load, and without any impedance coils or resistance between them. They run parallel perfectly.

(2) A considerable inductionless load was then put on, varied, and taken off. They ran equally well under all circumstances.

(3) They were uncoupled, and then, the load being connected to the mains, they were suddenly and simultaneously switched parallel and on to the mains with perfect success.

(4) One alternator was excited to give 1,000 volts, the other giving 2,000 volts. They were then switched parallel, and went into step perfectly, giving a terminal P.D. of about 1,500 volts. No impedance or resistance was used in this or in any other case. A load was then put on without affecting their behaviour.

(5) With one machine at 1,000 volts, and the other at 2,000 volts, they were switched parallel *when out of phase*, and instantly went into step. A large current appeared to pass between them for a fraction of a second, but not nearly long enough to enable it to be measured, or to do any harm.

(6) They were then left running parallel while one was disconnected from the engine, by its belt being shifted from the fast to the loose pulley. It continued to run as a motor synchronously. A load of lamps was at the same time on the circuit.

(7) The two machines were then uncoupled and excited up to 2,000 volts. They were then switched parallel when out of phase and without any external load, and went into step instantly.

(8) Whilst running as in (7) steam was suddenly and entirely shut off one engine. The alternators kept in step perfectly, one acting as a motor and driving the large engine and all the heavy counter-shafting and belts. It was impossible to tell, except by the top of the belt becoming tight instead of the bottom, which machine was the motor.

To find the power exerted by the alternator acting as a motor (in 8), a direct-current motor was put in its place, and the power required to drive the engine and shafting was found to be 20 h.p.

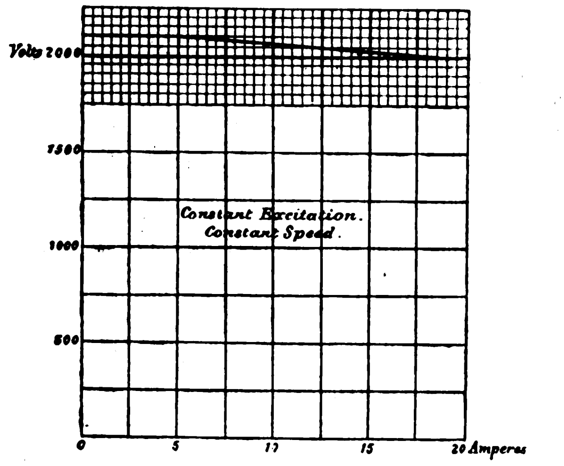

Fig. 1.—Characteristic.

It may be pointed out that these tests were made under the most exacting and onerous conditions that could possibly be imposed, and particularly I would point out that on account of the very great momentum of the revolving masses, nothing but the strongest and most instantaneous motor action could have kept the machines in phase. There never was a single case when they got out of step, even momentarily, or when subjected to sudden and violent variations of load. When it is considered that, in order to secure this result, it was imperative that the control of all that mass should be exerted in a fraction of $\frac{1}{100}$ of a second (the periodicity being 100), it will be recognised that there was no time to be lost, and that the use of any self-induction or resistance, or of anything else that could in any way choke, retard, check, or interfere with the strength and instantaneity of the action was above all things to be avoided.

I should mention that the machines apparently synchronised equally well at speeds varying very considerably.

As to the self-induction of the machine itself, that is quite negligible. Its characteristic, Fig. 1, is nearly straight, about half the drop in the curve being due to resistance, and half to self-induction.

Here was a machine generally allowed to be good when working singly, but possessing all the qualities that have been stated as unfitting it for parallel work, tested under all the conditions that are recognised as most trying, even for those types of alternators which are universally, and I believe erroneously, regarded as best suited for parallel work, and behaving throughout in a manner that simply left nothing to be desired, and carrying, unimpaired, into parallel work those features which it possesses when run singly.

I trust that I have now said enough to justify the views I have expressed.

A few particulars of this machine may be of interest. It now takes 500 watts to excite it at full load, and rather less than 400 watts on open circuit with full E.M.F. The efficiency when working with a light load is very high. The power required to run at full speed, with full E.M.F., but no external load, is 3 h.p., of which 1·5 h.p. is ordinary mechanical loss in the bearings, etc., and 1·5 h.p. is electrical waste in the armature conductors and supports. This is from a most careful test, and shows that, so far as economy is concerned, with light loads the machine does not leave much to be desired. This is really of very great importance, for the expense connected with central station working during the long hours of daylight may be a serious item.

Alternate-Current Motors.

The bearing of the foregoing on the great and vital question of the construction of alternate-current motors is obvious. Much work has been done of late on this subject, and no doubt considerable success has been met with, but the use of alternators as simple synchronising motors has not appeared to attract much attention, probably because it is not known what excellent results may be obtained in this direction, and partly because of their inability to start from rest.

The experiments just described, and others that I have carried out, showed what perfect self-governors such motors are. Not only do they maintain synchronism, but they possess an inherent economy which is most valuable. Just enough current passes through them to keep them in step, and to do the work imposed on them. They become generators, and do work on the circuit, if from any cause there is a tendency for them to run faster than the generator.

I have devised a very simple means of starting such motors, which at a small expense removes the only drawback to their employment. The exciter, which is geared directly in some way with the alternator, is used in conjunction with a small accumulator, as a direct-current motor to start the alternator. When synchronism is attained, the latter is simply switched into circuit. It will be obvious that a small battery capable of a heavy discharge for a minute or two is all that is required. This is recharged by the exciter. I need not go into the details of the arrangements. This is perfectly practical. I should have no hesitation in running these alternators in regular work as motors, and should expect to find their "commercial efficiency" very nearly or quite 90 per cent.—about the same efficiency, whatever it is, that they possess as generators. For instance, the machines alluded to will work as motors at a useful output of 50 h.p. with this efficiency.

And here is another advantage in getting alternators economical when on open circuit. By doing so it becomes possible to use the very small exciter as a direct-current motor to get them up to the synchronising speed.

In many situations a synchronising A. C. motor will fulfil all requirements, and will do so with fewer drawbacks than any other kind of electric motor whatever. It will be a better regulator, more economical, less troublesome to look after, much safer to handle, and —what is of very great importance in connection with the transmission of large powers to a distance—the difficulty of dealing with high pressures, which is so serious with direct-current motors, is very easily overcome, for not only will alternators stand a higher tension in themselves, but, if necessary, transformers may be used to reduce the pressure between mains and motor.

Periodicity.

Some confusion is caused by the various ways in which rates of alternation are expressed, it being often quite uncertain whether periods or half-periods are referred to when "alternations" or "reversals" are spoken of. This confusion should be avoided by using the term "period," which has, I think, always been taken as expressing the complete cycle, or the changes undergone by a simple rectangle or elementary armature rotated from zero through a complete revolution in a simple magnetic field. To save confusion I would suggest a sign be used, unless a better one be forthcoming, and that we agree to speak of periods, instead of alternations or reversals, and of periodicity, instead of frequency or rates of alternation or of reversal.* Prof. Silvanus Thompson informs me that formerly a somewhat similar difficulty arose in regard to sound, and that confusion was avoided in the science of acoustics by giving the word "vibration" the definite meaning of the double motion which it now possesses, the French tuning-forks being stamped with the letters "V.D." (*vibration double*) after the number.

The subject of periodicity is becoming a very important one, for both commercial and scientific reasons. It urgently demands settlement in the interests of the whole industry. The very wide differences found in scientific opinion on this matter, and in the practice of the various manufacturers, must lead, and are indeed now leading, to much confusion and inconvenience. As things stand at present, great uncertainty exists not only as to what rate is the best, but whether transformers, arc lamps, or other apparatus made by one maker, for a given E.M.F. or purpose, can be used on a circuit, fed from an alternator constructed by another maker. It might be suggested that some joint action should be taken by manufacturers and others concerned, in the direction of securing uniformity; but there are arguments against such a course, the principal one being that probably each maker believes he has good reasons for his own practice.

I venture to think there is no right or wrong periodicity. What may be best for one set of conditions, or with one type of apparatus may not be best for another. Or, perhaps, it would be more correct

* This sign may be written something like, but rather larger than the algebraic sign for "difference."

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to say that there is a right periodicity, and that there are right and wrong apparatus; but this is rather a delicate subject.

The relative advantages of high or low periodicity must be considered as bearing on the five main divisions of apparatus used. Taking these in their natural order they are:

1. Prime Motors.
2. Alternators.
3. Conductors.
4. Transformers.
5. Lamps, etc.

Each of these divisions contains matter in relation to periodicity which in the near future will probably form the subject of many papers as the various subjects become better understood. I am not able to do more than touch briefly on each, in the hope that my remarks may lead to the expression of the views of others, and to some approach to uniformity.

1. *Prime Motors.*—At present questions affecting prime moters do not usually bear directly on the subject of periodicity. The only exception is the Parsons steam turbine, with which there seems to be no great difficulty in using a simple two-pole machine, thus making the number of revolutions and of periods the same. There may be found some want of flexibility as regards changes of size or output with such turbines, as, from the nature of the case, speed can only be varied by very large amounts. Thus, for instance, if 100 periods are required, there is no choice except between a two-pole machine at 6,000 revolutions per minute and a four-pole machine at 3,000 revolutions. This is, of course, on the assumption that the alternator is driven direct. If indirect driving is resorted to, the difficulty is much reduced. It is unlikely, however, that the bearings of a steam turbine would work satisfactorily except with direct driving.

2. *Alternators.*—It is not allowable to doubt that the divergencies in periodicity found in practice are to a great extent the result of development and survival of what has been found to give the best results in each case; but from an examination of the machines in use it is very difficult to trace any common line on which action may be supposed to have taken place. It is true that the general tendency has been towards a reduction of the periodicity, but the causes which are responsible for that tendency are very obscure. I have seen large and small machines, made at the same time by one maker, in which the number of coils was the same, although one had to run at about 2,000 revolutions a minute, and the other at less than half that rate of speed. At least one of these was wrong. For the purpose for which these machines were made the very high periodicity was almost unobjectionable in the small machine, but in the large ones it led to disaster.

It is a common mistake to suppose that high speed of driving, or high peripheral velocity, are necessarily connected with high periodicity and with large output. Of course any given machine, if run at a higher rate of speed than its normal one, must have a proportionately higher periodicity, but will not necessarily be capable of a greater output. It is quite possible to design a high-speed machine to give a low periodicity, and *vice versâ*. Perhaps the impression has arisen because with most alternators it is not possible or desirable to place the successive poles very close together on account of the magnetic leakage.

For machines with iron in the armatures, it might be expected that the magnetic and electric losses, as well as the very considerable self-induction and consequent variations in the effective potential differences with changes of load, would lead to the reduction of the periodicity; but experience does not seem to have always led to this result. The lowest periodicity (42 with the Zipernowski machine) and the highest (132 with the Westinghouse machine) are both found in alternators having iron cores. What is the reason of this great diversity? The machines have many points of resemblance, and yet one is run at more than three times the periodicity of the other. Not having seen the American machine, I can offer no opinion based on personal observation; but of the Austrian alternator I can say that, in my opinion, it would not be advisable to increase the rate.

In a communication from Messrs. Ganz and Co., published a few days ago,* Mr. Zipernowski says that the low periodicity used was chosen on principle to enable them to couple their dynamos parallel. He very cogently adds, in justification of this: "At present no practical electrician will hesitate to acknowledge the coupling of dynamos in parallel circuit to be a vital question of any parallel system of central station distribution."

This bears out very completely my contention that the periodicity is governed in most cases by some special feature of the type of apparatus. Zipernowski has had to go down to 42 periods to get his iron-cored alternators to synchronise, and for no other reason; for his statement is that synchronous action was "not a secondary result, but just the end we were aiming at," and he acknowledges that there are disadvantages connected with this low rate in other parts of the system.

But Westinghouse with 133 periods, and Lowrie-Parker with 80—both having iron cores—can run parallel: the former with not less than half-load; the latter, as we now know, with any load; and I think I could run parallel without iron and at any load and periodicity, so that Mr. Zipernowski's only reason fails to justify his action, except as regards his own particular apparatus.

Prof. Forbes recently stated that the exhaustive tests made in America with the Westinghouse apparatus had shown that there was no reason for reducing the rate of alternation, which is the highest now in use. This is very important, and it is to be hoped that some account will be given of the nature of the trials and of the results obtained. Mr. Ferranti, who at one time used very high rates, has for some time been using 80 periods at the Grosvenor Gallery, and has fixed 68 periods for the Deptford machines. I shall not be surprised to see him increase this before long.

In my own machine the periodicity is 100, which, I believe, is on the whole the best rate; but if it be required to do so for any special purpose, there would not be much difficulty in changing it. The pole faces can be altered in number and in size by merely altering the pattern. The field-winding, being in a single coil, would be equally simple and equally efficient for any periodicity. Even with a large number of poles placed close together, as would be required for a high rate, magnetic leakage would not increase. The size of the machine would not be sensibly affected. The armature would certainly be rather more costly for a high rate, as a greater number of coils would be required; but the efficiency, output, and regulating qualities would remain practically the same. Regarding this machine, I think I may say that periodicity is not a question of the first importance. As far as I am concerned, it is other divisions of the distributing apparatus that determine the rate at which it is desirable to work.

The bearing of the form and arrangement of any alternator on the best periodicity for that alternator is a very close one. The question cannot be settled on general principles.

I have referred elsewhere more fully to the conditions as they affect regulation under varying loads, parallel working, and other points in connection with alternators; and, as an appendix (see p. 20), I have quoted some observations made recently at the Institution of Civil Engineers during the discussion on Mr. Kapp's paper on "Alternate-Current Machinery," and not yet published.

I now pass on to the next division of the subject.

3. *Conductors.*—The choice of a suitable periodicity depends also to some extent upon the conditions as they affect the conductors.

The effect of rapid alternations in virtually increasing the resistance of conductors has been brought before us in Sir William Thomson's presidential address, and it becomes necessary to recognise clearly what practical limitations are imposed by this effect.

My attention was drawn to this matter two or three years ago, when I was called upon to examine and report upon an installation of about 1,000 100-volt lamps supplied directly by an alternator working at about 150 periods. It was found that there was a very serious drop of potential in the conductors, and, in consequence of this, the lamps could not be maintained at full power. On examining the circuit I found the cables were of ample size, and that the loss could not be explained in the usual way. As a result, I came to the conclusion that it was to be accounted for only by some kind of inductional action, due to the alternating current, and I advised that a direct-current dynamo should be put down in place of the alternator. This was done, and with a perfectly satisfactory result. The lamps were for the first time run at their proper power, and no further trouble was experienced.

At that time I was, like most other electricians, a disbeliever in alternating currents, which I vaguely regarded as essentially unsatisfactory. I think there was a more substantial basis for this opinion than is now generally admitted. Alternating currents as then most often used were not satisfactory; and if great care is not taken at the present time, some of the old difficulties will be encountered, with the result of unnecessarily discrediting the transformer system of distribution.

(*To be continued*).

ON LIGHTNING, LIGHTNING-CONDUCTORS, AND LIGHTNING-PROTECTORS.

The following is an abstract of the discussion which took place upon the reading of Dr. Lodge's paper on the above subject at the Institution of Electrical Engineers.

In opening the discussion, **Mr. Preece** said he did not wish to appear as antagonist of Dr. Lodge, but as a defender of the Lightning Rod Conference and the "older electricians," and as an advocate of "experience" as distinguished from "theory." Those of the older school were guided by and had a great veneration for facts, whereas the deductions of theory were based on assumptions guided by mathematics, and were not always true. Referring to case *a* (steady strain), he contended that no difference of opinion existed, and that this was the case taken up by the conference. With regard to the relative merits of iron and copper for conductors, the conference considered the question judicially and recommended copper, chiefly because of its greater durability. He himself always advocated iron, and considered a No. 4 galvanised wire amply sufficient for ordinary conductors. As a proof that self-induction was not ignored by the conference, a passage from the report was quoted which states that the suddenness of lightning discharges affects the conductivity. Coming to case *b* (impulsive rush), great difference of opinion exists. Though he had no doubt about the reality of the phenomena shown in Dr. Lodge's experiments by the aid of Wimshurst's machine, yet he contended that the deductions drawn from them were not necessarily true, that Leyden jar discharges were not comparable with lightning flashes, and that the tin plates used to represent clouds differed greatly in conductivity from clouds, which, on the authority of Dr. Lodge, are very imperfect conductors. He considered that the conditions of the experiments more nearly imitated a broken conductor, and mentioned that many similar experiments were made fifty years ago by Mr. Andrew Cross. As regards the oscillatory character of discharges, all agreed that Dr. Lodge had shown that Leyden jar discharges could be made oscillatory by introducing self-induction, but he (Mr. Preece) thought there was no conclusive evidence that lightning flashes were so. On the contrary, telegraphic records of flashes made by Bain's chemical system, Thomson's

* The *Electrician*, May 10, 1889, p. 16.

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recorder, and Wheatstone's receiver, show no signs of oscillation. A recent case was described in which a Wheatstone receiver was kept running during a thunderstorm in Anglesea on Sunday, the 5th inst., and the resulting tape was exhibited. Further evidence of the unidirectional character of the current was said to be afforded by the signs of electrolysis exhibited by some conductors, which had been broken by flashes. He had also examined wires fused by lightning in which the fusion appeared to have started in the interior, whereas, according to Dr. Lodge, the current is confined to the outer layers. This, the speaker submitted, tended to disprove the theoretical deductions, and thought that the fact of telegraphic instruments always being fused inside the coils pointed in the same direction. Referring to lightning-protectors in general use, experience proved that instead of such things being of the "most utterly imperfect kind," they were of immense service, for in the Navy no accident had been recorded since 1872, and in the Post Office telegraphs not a single pole out of half a million had been damaged. In 1872, before the instruments were fitted with protectors, 19 per cent. of the instruments in use were damaged; but now the percentage is reduced to 1·3, and this he believes due to the non-protected instruments still in use. Several conclusions of the Lightning-Rod Conference had been severely criticised by Dr. Lodge in section 39 of his paper, particularly those relating to the protection afforded by well-earthed conductors, and in reply to this criticism Mr. Preece said he was quite prepared to clasp a good conductor during a storm, or even to sit on a barrel of gunpowder through which the conductor passed.

Mr. C. W. Vincent, speaking of oscillations, said that he assisted Faraday in making experiments on the discharge of a large Leyden battery through various materials, but no signs of oscillation were noticed, although cases of intermittent discharge were frequently detected.

Mr. Farquharson described a singular case of damage to H.M.S. "Coquette," in which part of the conductor passing from the mast to the copper sheathing of the vessel was torn away from the beam to which it had been attached. The only defect found in the conductor was a bad joint near the top, and he could never understand how this defect could cause the observed effect.

Mr. J. Wimshurst considered that there was nothing very new in the impulsive rush, for he had been acquainted with it for some years. As regards the protection afforded by points against an impulsive rush, this depended greatly on whether the cloud was positively or negatively electrified. To show this, a dome and point were placed on the lower of two insulated metal plates, and Leyden jars discharged into the upper. When the top plate was + the point was struck equally with the dome when both were at the same height, but when the electrification was reserved the point afforded great protection. This difference is of consequence in Dr. Lodge's "bye-pass" experiments, and he (Mr. Wimshurst) had found that putting on the bye-pass reversed the direction of the spark across the air space.

Prof. W. G. Adams said that, as chairman of the Lightning-Rod Conference, he thought the work done by that body had been misrepresented and unfairly criticised, for its objects were to examine and report on what was then known on the subject, and to condense existing knowledge so as to form a scientific basis for future practice, and these objects he considered were well carried out. He acknowledged that Leyden jar discharges produced remarkable effects then unthought of, but considered the statement that lightning flashes were strictly analogous unproved. As illustrating the truth of the older views, the case of Brussels Town Hall was cited. This building, although elaborately protected on M. Melsen's system, has been recently struck, thus proving that the adverse opinion expressed by the conference on the system adopted to be well founded. Another case in which the views of the conference received confirmation, occurred at the South Foreland Lighthouse, in 1885. The flash struck the lantern, leaped to the electric lamp, passed through a long cable to the magneto machines, and thence, by way of the engine-room conductor, to a well 280ft. deep, into which the conductor was earthed. The lighthouse conductor, where seen, was in perfect order, but the earth plate was found buried about 18in. below a gravel path, resting on dry chalk. A man standing within a foot of the spark as it passed to the electric lamp felt no shock.

Prof. Fitzgerald, on rising, said he had said nearly all he had to say at Bath, but he wished to point out that the data now brought forward by Mr. Preece did not prove the non-existence of oscillations, for in all discharges, whether oscillatory or not, there is a definite flow in one direction, which would produce the telegraphic records. Referring to Dr. Lodge's paper he said the weak point was the assumption that clouds behaved like good conductors, for it was well known that in horizontal directions they were very bad conductors. Of course it was possible that a shower might make them good conductors vertically, but this was a point on which no reliable data existed. Before Dr. Lodge's experiments, the speaker said it would have been very difficult to account for the setting fire to the Hôtel de Ville at Brussels by sparks from an isolated bar of metal, and although the Lightning-Rod Conference had done much good work, there were still many obscure points requiring experimental examination.

At this stage of the discussion, **Dr. Lodge** (who was unable to attend the next meeting) briefly replied to some of the questions raised. With regard to experience *v.* theory, he considered that theory, guided by experiment, more likely to make progress than unguided experience. Owing to lack of theory, Edin called into existence "etheric force" to explain phenomena of a character similar to those produced by electric surgings, and Mr. Mascart had observed similar phenomena, but had not described them because he could not understand them. Mr. Preece had said that no difference existed between them as regards case *a*, but this Dr. Lodge thought was not correct, for he maintained that surgings occur in case *a* as well as in case *b*; and he could not admit that when there was no oscillation, there was no self-induction, for self-induction existed in every circuit. Judging from Preece and Sivewright's telegraphy, he concluded that lightning-protectors frequently failed, and to be really efficient, no single failure should occur. Referring to Mr. Wimshurst's experiment, he said that he had not noticed any difference between the different protective effect of points with charges of opposite sign, for he never troubled himself about the matter of sign. In conclusion, Dr. Lodge expressed his opinion that the Lightning-Rod Conference did much good work, and regretted that he should have seemed antagonistic towards it.

The discussion was then adjourned to May 16, when Mr. Wimshurst proposed to show his direction "analyser" in action as well as other experiments bearing on the subject under discussion.

Mr. Wimshurst, on resuming the discussion on 16th inst., reperformed his experiments on the difference in the protective power of points when the clouds are positive or negative, and said that in the latter case the point might be 2¼ to 2½ times as far away from the cloud as a dome, and still protect. The reversal of the direction ot the "*b* spark" by putting on a "bye-pass" was also shown, together with experiments indicating that imperfect earth greatly increases the tendency to side flash, and that this tendency is further increased by augmenting the size of the body receiving the flash, and by connecting it to earth. In view of these facts, the experimenter considered that the conclusions of Dr. Lodge respecting the small importance of good earth, and the propriety of connecting all pieces of metal together, and to the earth, needed reconsideration. Side flashes were also taken by Leyden jars, and in some cases they were found uncharged when tested, whilst in others the charge remained. An experiment analogous to the sparking seen on the gilding of the walls during Dr. Lodge's experiments was next shown, in which sparks passed between separate pieces of foil, forming a spangled outer coating of a Leyden jar, when an insulated body within the jar was connected to an influence machine at work.

Prof. Hughes said he did not agree with Dr. Lodge's statement that the "older electricians" never contemplated case *b*, for Sir W. Snow Harris had recognised the difference, and from experiments made by Prof. Guillemin, M. Bertsch, and himself, in an investigation on lightning-protectors (see "Annales Telegraphique," 1865, and *Electrician*, July 13, 1888), it was concluded that Leyden jar discharges differed from ordinary lightning, for it was well known that protectors did protect instruments, whereas in their experiments with large jars nothing protected them. He also considered it unfair of Dr. Lodge to take all the credit of having recognised the distinction between cases *a* and *b*, and the influence of self-induction, to himself, altogether ignoring his predecessors in the field, for Prof. Guillemin showed that a sheet of tinfoil might protect an iron wire, whereas the same foil rolled up like a wire failed to protect. As regards iron *v.* copper, his (Prof. Hughes') experiments prove that for rapidly varying voltaic currents copper is decidedly superior, and the preference now given to copper for telegraphic and telephonic work points to the same conclusion. It had also been shown that iron wire was circularly magnetised by discharging a Leyden jar through it, and the production of this effect would, he considered, retard the discharge.

Mr. G. J. Symons thought Dr. Lodge did not realise the alarming nature of his own remarks in reference to the rules of the Lightning-Rod Conference. As a member of that body, he was anxious to improve the rules wherever possible, but considered it injudicious to discard well tried and safe rules until something better had been devised and tested by experience. As regards points *v.* knobs, the subject had been thrashed out 120 years ago. The Lightning-Rod Conference had recognised the importance of hot-air currents, for they recommended that house conductors should be fixed to the kitchen chimneys. The dimensions of conductors was next referred to, and from the fact of large ones having been fused, the speaker thought Mr. Preece should not recommend small wire. He also stated that although the existence of a "protected area" around a conductor was disputed, yet much evidence pointed in that direction.

Colonel Armstrong, R.E., speaking of the protection of magazines, said he believed the War Office were the only body who had regular and systematic earth-resistance tests made on their conductors. From his experience in the matter he could say that no accident had ever happened to a magazine whose conductors made good earth, as shown by the regular tests, whereas several had occurred in cases where the earth was bad (say 200 ohms). In one case the conductor was fused below the point at which the main flash left the conductor, and this he believed due to want of continuity at the lower place. In another case cartridges packed in a sealed metal case were exploded by a lightning flash, thus showing that currents were not confined entirely to the outer layers as Dr. Lodge supposes.

Mr. A. J. S. Adams considered wires carrying varying currents to be under stress, and that such stress was relieved by radiation from the wire. The amount of this so-called radiation he takes to be a measure of the opposition offered to the passage of the current, and says that copper radiates about 25 per cent. less than iron or brass.

Mr. Spagnoletti said telegraph wires were very seldom fused, although instruments were frequently damaged, and, as an instance of such wires conveying large lightning currents, cited a case in which a lineman was killed by touching a wire which was struck by lightning at a point 50 miles away. He also asked whether lightning flashes had been proved to be oscillatory?

Mr. S. Evershed described some observations he made in 1877, which tend to show that the "*b* spark" does occur in nature. A thunderstorm was in progress about five miles from his place of observation, where he had a goldleaf electroscope and a quadrant electrometer connected to an insulated plate about 6ft. high. In the intervals between the flashes the leaves remained open about ⅛in.; but instantaneously with each flash they opened to three times that amount. The spot of light from his electrometer disappeared with such rapidity that he could never say in which direction it moved.

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These facts also show that Nature is not always "slow and solemn," as Mr. Preece would have us suppose; and the peculiar effects exhibited at Antwerp railway station prove that lightning does not always behave in accordance with the views of the Lightning-Rod Conference. Referring to Mr. Preece's supposed proofs from telegraphic records that flashes are not oscillatory, Mr. Evershed pointed out that such records would be produced, even if oscillations were present, for a greater quantity of electricity passes in one direction than in the other.

The **President**, Sir W. Thomson, in closing the discussion, thought Dr. Lodge's paper a most interesting and valuable one, and the Institution was greatly indebted to its author for bringing the matter so prominently forward. All admit that the importance of self-induction was not sufficiently recognised previously. He could not say whether Franklin knew of its existence, but Sir W. Snow-Harris did, and many views held by the latter, which until recently were condemned, have now been proved correct. Referring to section 56 in the paper, he thought Dr. Lodge did not mean what was there stated as to the shape of section of the conductor, for it was quite certain that flat ribbon had much less self-induction than round rod. As regards gas and water-pipes as earth, Sir William considered that they made a good earth, and he did not see much danger in connecting pieces of metal with the lightning-conductor in cases where other earth could be obtained. In view of Colonel Armstrong's statement about cartridges being exploded when completely enclosed in metal casings, he thought it important to try if iron cases afforded more protection than brass or copper ones, for it was probable that the magnetisation of the iron by the currents would produce additional screening. Faraday's electric cage experiment should also be repeated, using the more sensitive apparatus since devised to search for any internal effect. In conclusion, the President said the report of the Lighting-Rod Conference is a very important work, and though some flaws may exist, yet, on the whole, experience gives very strong reasons for believing that the rules are good.

PHYSICAL SOCIETY.—May 11.

Prof. Reinold, President, in the Chair.

Mr. A. Clegg, Prof. V. B. Lewis, and Mr. W. Robinson were elected members of the society.

The following communications were read:

"On an Electrostatic Field produced by varying Magnetic Induction," by Dr. O. J. Lodge, F.R.S. This paper describes a research made with the object of finding some connection between static electricity and magnetism. Several methods of attacking the problem, such as rotating or varying the strength of magnets in the neighbourhood of delicately suspended charged bodies, are indicated, and the one selected was based on an idea of Mr. A. P. Chattock, who conceived that a charged body in the vicinity of a closed magnetic circuit would be affected by varying the magnetic induction. From the theory of the effect it is shown that the magnitude of the quantity sought is exceedingly small, for the expression involves the inverse square of the velocity of light. The E.M.F. induced in any closed curve round the magnetic circuit or solenoid, by varying the induction I, is given by $e = \frac{dI}{dt}$ (1). If an E.M.F., e, act on a charge, Q, at distance, r, from the axis of the solenoid, the work done in one revolution will be e Q, and $e\,Q = F\,2\pi r$ (2) where F is the mechanical force. Now if the E.M.F. in (1) is the same as that in (2) the impulse given to the charged body by destroying the induction will be $\phi = \int F\,dt = \frac{I\,Q}{2\pi r}$ (3). Since $I = \frac{4\pi n C A \mu}{l} = \mu$ C times a length, and $Q = sV$ = K V times a length, $\therefore \phi = \frac{K \mu C V A}{2\pi r}(\text{length})^2$ and $K\mu = \frac{1}{\text{“}v\text{”}^2}$

$\therefore \phi \propto \frac{1}{\text{“}v\text{”}^2}$

The magnetic circuit actually used was a wire Gramme ring of trapezoidal section wound with copper over only a part of its periphery. The indicating apparatus was a suspended needle, consisting of two oppositely charged bodies carried on a small shellac arm, to which a mirror or pointer was attached, and was suspended vertically in the plane of the ring. Great difficulty was experienced from the Foucault currents when metallic films were used for the needle, and the magnetic properties of other semi-conductors tried further complicated the matter. Eventually the charged bodies were made of paper in the form of cylinders ¼in. diameter and ¾in long. Considerable trouble was caused by the electrostatic action between the needle and exciting coils, and various methods of screening were tried and abandoned, and subsequently the wire was replaced by a single spiral of copper ribbon, the outer turn of which was put to earth. Observation was rendered difficult owing to the wandering of the zero when the needle was charged, but this was minimised by suitably shaping the contour of the needle's surroundings. Heat also created considerable disturbance, and the convection currents were cut off by a series of concentric cylinders of tinplate. The method of observation was to charge the two insulated parts of the needle, and then reverse the magnetising current in synchronism with the period of the needle, noting whether the amplitude of any residual swing could be increased or diminished according as the impulse assisted or opposed the motion. In this way slight indications have been observed, and the effects reverse when the charges of the cylinders are reversed. In explaining the theory of the experiment, the author made use of a simple transformer, consisting of an ordinary hank of iron wire wound over with insulated copper, and provided with several secondary coils, and by it he demonstrated that the primary current increases on closing the secondary, due, as was shown, to the decrease of self-induction of the primary caused thereby.

Prof. Fitzgerald, in answer to a question from Dr. Lodge as to the influence of screens, said he had not fully considered the matter in this particular case, and as the general effect of screens depended on the square of v, the subject required careful treatment. As a means of checking the results obtained by Dr. Lodge, he suggested calculating the impulse, and seeing whether its magnitude approximately corresponds with that observed. Commenting on an idea for carrying out a similar experiment, attributed to him in the paper in which a charged gold leaf is placed between the poles of a magnet, Prof. Fitzgerald said he had been misunderstood, for he had conceived a disc parallel to the faces of the magnets which, when excited, should cause the disc to turn in its own plane. Referring to the equations for mechanical force given in Maxwell, section 619, he pointed out that the coefficient of e in the equation $X = ev - bw - e\frac{d\Psi}{dx} - m\frac{d\Omega}{dx}$ ought to be P, where $P = cy - bz - \frac{dF}{dt} - \frac{d\Psi}{dx}$, and considered it very important that the existence of the term $e\frac{dF}{dt}$ should be tested experimentally.

Prof. S. P. Thompson mentioned some experiments on which he was engaged, by which he hoped to show electric displacement in continuous dielectric circuits, such as a hank of guttapercha. Up to the present, the experiments had not been successful, owing to his inability to place the two Gramme ring coils used into such relative positions as to give silence in the telephone connected with the coil used as secondary, when currents were sent through the primary.

Prof. Ayrton suggested that Dr. Thompson's difficulty may arise from the fact that such rings do produce considerable external field, even when carefully wound.

Prof. Fitzgerald requested Dr. Thompson to investigate the effects of displacements currents and of changing vector potential, and pointed out that in a single medium the former can produce no magnetic effect. As regards fields containing different media, he said the calculations would be complicated by the spurious charges on the separating surfaces.

Dr. Lodge, in reply, said he had calculated the momentum to be expected in one arrangement of his experiment in which a suspended aluminium cylinder surrounds one limb of a rectangular magnetic circuit which formed the core of an induction coil One end of the secondary was put to the core, and the other to the cylinder, thus forming a condenser. The result came out about 10^{-6}dyne second, but he could not say whether such a small quantity was observable.

"On the Concentration of Electric Radiation by Lenses, by Dr. O. J. Lodge, D.Sc., F.R.S., and James L. Howard D.Sc.

The authors' first attempts at concentration were made with mirrors on a comparatively small scale, and owing to the difficulties experienced, it was considered advisable to try lenses. Two large cylindrical ones of plans hyperbolic section were cast of mineral pitch in zinc moulds, the plane faces being nearly a metre square, and the thickness at vertex 21cm., and each lens weighed about 3cwt. The eccentricity of the hyperbola was made 1·7 to approximate to the index of refraction of the substance. The lenses were mounted about 6ft. apart, with their plane faces parallel and towards each other on a table in the college corridor, and an oscillator was placed about the principal focal line of one of them at a distance of 51cm. from the vertex. The field was explored by a linear receiver made out of two pieces of copper wire mounted in line on a piece of wood, and an air-gap between their inner ends was adjustable by a screw. When the oscillator worked satisfactorily the receiver would respond to about 120cm.; and with the lenses the distance was 450. The receiver responded anywhere between the lenses and within the wedge between the second lens and its focal line, the boundaries being clearly defined, but no special concentration was noticed about the focus. Interference experiments were carried out by placing a sheet of metal against the flat face of the second lens and determining the positions of minimum intensity between the lenses. The distance between these points was 50·5cm., corresponding with a wave length of 101cm. whereas the calculated wave length of the oscillator was 100c.m.

Prof. Fitzgerald congratulated the authors on their success, and also pointed out that although large oscillators give good results at distances within a few wave lengths, yet at greater distances small ones were decidedly superior, owing to the energy of radiation varying as the fourth power of the rapidity. He had recently made experiments on electric radiations analogous to Newton's rings, and had successfully observed the central dark spot and the first dark band. Referring to Dr. Lodge's experiments, he enquired whether any traces of diffraction were observed near the boundary of the bundle of rays between the lenses. Speaking of polarisation experiments, Prof. Fitzgerald said waves reflected from films of water exhibited no polarisation, whereas those reflected from non-conductors were completely polarised.

In reply, **Dr. Lodge** said no diffraction effects had been observed, but in the interference experiments to determine wave length, the positions of minimum effect were very decided.

The **President**, in proposing that the thanks of the meeting be given to the authors of the papers, congratulated the society on the presence of both Dr. Lodge and Prof. Fitzgerald on the present occasion, when subjects with which they were so well acquainted were brought before the meeting.

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BOARD OF TRADE ENQUIRY.

SATURDAY, APRIL 27.

Major Marindin, C.M.G., R.E., on behalf of the Board of Trade, resumed the enquiry at the Westminster Town Hall, for the purpose of hearing, on the part of a number of electric lighting corporations, their provisional orders to erect and maintain electric lines and works, and to supply electricity within certain areas in the metropolis and elsewhere, and the objections raised thereto by other companies and corporate bodies.

Mr. Wallace, who represented the Kensington and Knightsbridge Electricity Company, replied to the various objections raised by the Vestries of St. Mary Abbott's, St. Margaret's, and St. John's, most of which he said his company were willing to meet.

Mr. Shiress Will replied for the House-to-House Company, but raised no question of public importance.

Mr. Wallis, who represented the Westminster Electric Supply Corporation, said that his company had chosen sites, and had already used an amount of preliminary capital in erecting a station for the supply of 5,000 lights. How had the London Company gone to work? They started at the Grosvenor Gallery, and laid down an installation which it was admitted they had had to abandon. Moreover, the capital that they had used to commence a system of overhead wires was wasted. They did not in the first instance apply for a provisional order, but attempted to appropriate certain portions of London in an illegitimate manner. In other words, they spent their money, erected a station, and laid down their plant on no security whatever, instead of waiting to see whether or not they would get their provisional order. He (the speaker) ventured to say such a company as the London ought not to be trusted with the lighting of any portion of London, and he was convinced that the Board of Trade would share that conviction. Besides, Sir William Thomson said that their system was a gigantic experiment. The local authority of St. George's, Hanover-square, were satisfied with the Westminster Company. As to St. Margaret's and St. John's parishes, Westminster, they refused all companies alike. His company abandoned the Strand, St. Martin's, and all places where their interests collided with those of the Metropolitan Company and the Electric Power Storage Company.

Mr. Moulton, Q.C., then began his address on behalf of the Chelsea Electricity Supply and the E.P.S. Companies, and said that the question of satisfying the Board of Board of Trade that sufficient capital was appropriated for the purposes of lighting ought not to be matter for the enquiry, but at the moment the Board of Trade called such evidence, both his companies were in a position to amply satisfy the body. He might even say for the E.P.S. Company that they had already satisfied the Board of Trade as to their financial strength for the duties they proposed to undertake. With regard to what had been said about the intention of the E.P.S. Company to obtain an order for themselves, and to transfer it to others for a profit, it would be open to the Board of Trade to keep the company as the undertakers.

MONDAY, APRIL 29.

Mr. Moulton, continuing his address, said that there was not the slightest intention on the part of the E.P.S. Company to transfer or sell its order at a profit. The real thing for the Board of Trade to do was to find out that there was capital which would be appropriated to the working out of the order, and that the persons who were going to work it were of such standing as to be entrusted with it. In referring to the question of system, and how the transformer system affected the need of further provisions, or justified a relaxation of the model order, he submitted that so far from justifying any departure from the model order, it only emphasised the importance of the obligations under it. The transformer system differed from the direct supply in this, that the natural inducements to do its work thoroughly, and make electric lighting a thing used from house to house, were absent. The London Company, it seemed to him, had seized on this great feature of the transformer system that it would enable them to hold the City against all competitors. Under the guise of inviting competition, he thought that company were asking the Board of Trade to sanction an attempt which would leave London as much at the mercy of a large corporation as it had hitherto been in the case of gas and water companies. For motive power the direct supply was the only form of supply that could be used. It had been suggested that somebody had solved the difficulty about the alternating motor, but to his mind it was all in the air. The transformer system proposed to bring electricity into every house under circumstances which would be dangerous to life and property. He quite admitted the value of the safeguards against possible danger, but it was not quite easy to see how, on some occasion, imprudence or carelessness would be avoided. He could not see that the transformer system was a cheap one, and no figures had been quoted to prove it. Its chief advantage lay in the fact that it was more suitable for straggling districts. Nothing had yet contradicted his argument that the direct supply was cheaper where they were not dealing with straggling districts, and the question here was really one of districts of manageable size. The London Company had pushed the transformer system to its legitimate consequences as far as electrical engineering was concerned, and made it possible to fix upon any part of their enormous area and light it from Deptford. Supposing they got their area, they would be able to do the best piece of the City for its day lighting, and the best piece of Chelsea, which would strangle the Chelsea Company, and the best pieces of the Strand and Marylebone. They had adopted a system which would enable them to take all the plums in the way of lighting over their area. He wanted to contrast the aims of the Board of Trade in 1883, and their means of carrying them out, and what were the aims of that company, and their means of carrying them out. The object of the Board of Trade was not to let a company have powers over a district unless there was a reasonable certainty that they would put the electric light within the reach of the whole of the people of a district. Certain districts were only with great difficulty given to the companies, and the only reason why the power of extension was given to them was that if they took the pioneer risk, it was only just to give them the chance of a moderate extension without having to go to the expense of a further application to Parliament. But the Board of Trade knew that the only object of such companies was to develop electric lighting. They had no opportunity of picking out the plums, and the allocation of capital was required. It was, moreover, understood that if they did not succeed in doing their work, other companies would be allowed to come in, a fact which they embodied in the well-known clauses of the model order. Now, he accused the London Company of deliberately intending to take the plums. What did the London Company undertake to do in the way of actual works? Not one single yard of main did they undertake when they lodged their order. They now undertook to do in Chelsea the same compulsory works as the Chelsea Company undertook to do in 1886 in order to get their small area. It was to give a mock appearance of equality with the Chelsea Company. The London Company had, moreover, left out the clause, "capital allocated to do these areas," with the obvious reason that they intended to light such bits as would prevent any other company coming in and doing their leavings, or even in competing with them in places which they did light. They had omitted that clause because it was fatal to their scheme. As to the cry of "no monopoly," there was nothing to justify the Board of Trade in now coming to a conclusion different from what they did in 1883, that potential competition and judicious districting were better for the public than competition within the same area. With regard to the breaking up of the streets, the matter stood where it did before, and the Board of Trade was not now willing to permit overhead wires any more than it was in 1883. The third thing that the Board of Trade relied upon was gas competition. Looking at what gas could do in 1882, he had no hesitation in say that competition was now much more severe since the gas companies had awakened up from their lethargy. Even mineral oil was a much more efficient rival than it was in 1882. If the rivalry to the electric light was considerable in 1882, it was much more considerable now. What justification was there for supposing that the gigantic system of the London Company would lead to cheaper electric lighting? Their charge of £5 a quarter did not look as if they were to do any small lighting at all, and there was no evidence that they did not mean to go up to their maximum. If the scheme broke down, it would discredit electric lighting altogether. As to the E.P.S. orders, the two parts applied for were Paddington and the Strand. He did not think that the Vestry would continue their opposition to a well-considered scheme. They were willing to allocate the capital, and had undertaken to put down £30,000, which, he thought, was all that could be desired.

Mr. C. A. Cripps afterwards replied for the Metropolitan Company, and in the course of his address said that Mr. Moulton had based his argument on two contentions: first, that districting, as against competition, was settled once for all by the Board of Trade in 1883. So far from picking and choosing, his company put the whole district on an equal footing. They had made arrangements for generating stations for 350,000 lights, they had 700 shares, their capital had been subscribed by the public nearly twice over, and they had power to increase it. The Chelsea Company, in contradistinction to them, was in the hands of contractors. In Paddington the E.P.S. Company were competing with the Metropolitan Company, which applied for the whole of the district, while the E.P.S. Company applied for only a part, and Mr. Dethridge had expressed a decided preference for the Metropolitan system. They had the assent of the Marylebone Local Authority. With regard to the South London order, Lambeth said that they preferred the Metropolitan to the London Company's system, because the former applied for the whole district, whereas the latter sought only about a fourth, picking out the best parts. It was very improbable that the Metropolitan Company, however, could comply with all the conditions desired to impose. Wandsworth wished them to go there, the local authority making as good terms as it could. There was no competition in Wandsworth, it being merely a question between the company and the local authority.

TUESDAY, APRIL 30.

Mr. C. A. Cripps, in continuation of his address for the Metropolitan Company, said that there were only a few preamble objections to his Mid-London order. They were urged by St. Margaret's and St. John's, Westminster, for the City, and the St. Giles's District Board of Works. St. Margaret's and St. John's said, "We think all provisional orders should be refused, and that the local authority should be allowed another year to consider the whole question." No evidence had been given on behalf of the Vestry, and he did not know why objection was taken. The Vestry had, however, specifically laid it down that if any order were to be granted they would be in favour of competition. As regarded the objection of the City to the system, he would say without hesitation that every criticism which had been advanced by Mr. Russell Griffiths was not against the Metropolitan Company, but against the London Electric Supply Corporation. No one electrical difficulty had been put forward as militating against the Metropolitan Company. He submitted that having modified the term of 21 years for purchase to 42 years, and having regard to Mr. Preece's opinion that the converter system with central stations was the best for the City, and that the Metropolitan Company were willing to go into it, there was nothing which ought to keep the City and the company apart. As to the Strand agreement between the District Board and the Metropolitan Company, Mr. Pember, on behalf of the London Company, had urged that it was an improper agreement, which should not be sanctioned by the Board of Trade, and that it was contrary to the policy of Parliament, as shown

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by the Electric Lighting Acts. Mr. Jones, for the St. Giles's district, took an entirely different attitude. He said that it was a very proper thing for the company and the local authority to come to such terms, but asked why similar terms should not be granted to the body he represented. There had been a suggestion of unfair advantage shown to the Metropolitan Company. The evidence amounted to this, that a letter was sent in identically the same terms to the London and the Metropolitan Companies, which was followed by negotiations with both companies; but as regarded the London Company those negotiations came to nothing, whilst they ultimately ended in an agreement with the Metropolitan Company which was now before the inspector, and the only possible suggestion of unfairness was that the Strand Board of Works did not disclose to the London Company the terms on which they were negotiating with the Metropolitan Company—which he ventured to say would have been an improper thing for that body to do. He then went into a detailed explanation of the various clauses in the agreement. He next came to the clause suggested by Mr. Moulton to protect the telephone companies. Mr. Moulton seemed to argue that the electric light companies were creating a nuisance, and they must for all time protect anyone who might be affected by the nuisance thus created, and therefore not only as regarded existing telephone wires but those which might be laid down in the future, they ought to come under terms to provide against all possible damage. He (the speaker) thought that a monstrous assumption. The right principle was that where a telephone company had laid down their system, and were in occupation, they had a right to be protected against any second company seeking to come in. Where they were first in possession they were entitled to the rights they had got, and if those rights were interfered with full compensation should be given. But if the Metropolitan Company were first in possession, they had a right to be protected in the same way. He then came to the subject of motors, and said that the evidence of the scientific experts was to the effect that the alternating system could be used with motors. In the system of the London Company he contended that there were many difficulties which Mr. Ferranti had not told them how he proposed to overcome. The London Company had not had a single expert to back up Mr. Ferranti, and he believed that there was an overwhelming preponderance of the scientific evidence in favour of the alternating system which his clients proposed.

Mr. Pember then commenced his reply on behalf of the London Electric Supply Corporation, and said that his case and that of the Metropolitan Company were undoubtedly the most important of the enquiry. The London Company would spend the whole of its £800,000, or more, if necessary, in lighting the district it had undertaken to supply. If at the end of 42 years the local authority bought up the undertaking without the station at Deptford, the plant there would remain in the hands of the company, but he was not at all afraid of such a contingency. A moderate-sized room would suffice for the distributing stations of the London Company. The reduction of the voltage from 10,000 to 2,400 was not experimental, but was being actually done at that moment. Their system, so complete and simple, was by far the newest and greatest stride taken in the application of electricity for many years.

WEDNESDAY, MAY 1.

Mr. Pember continued his address on behalf of the London Company, and said that he had been told that the inspector had stated at Brighton that the Board of Trade had determined not to adopt the new unit.

Major Marindin said that that was the case. He had been informed by the Board of Trade that they had decided to retain their own unit and not to take up the new one.

Mr. Pember urged that they should adopt the larger unit of 10,000 amperes, as in the case of the London Company, rather than that of 1,000 amperes, for the reason that was the price at 7½d. as was now charged at the Grosvenor Gallery. The smallest reduction which they could make in the charge would be ¼d., which would represent a reduction of 3 per cent., whereas in the case of a gas company, with the unit of 1,000 cubic feet, and a charge of 3s. 2d., the reduction was not of such serious consequence. It was impossible, he then proceeded to say, to conceive any simpler or better method for the supply of electricity to London than that of the London Company. The objection that had been raised constituted every objection which hostility, self-interest, and ingenuity could raise. The first objection was that of short-circuiting, which was connected with the joint, but Mr. Ferranti was not afraid of that, because experiments had been made from day to day during the enquiry, which resulted in showing that those joints had been found to stand an enormous pressure. Even Mr. Preece, when asked if the proposal of the London Company was a reasonable one, said it was simply a gigantic experiment, and a matter of pounds, shillings, and pence. Even from a commercial point of view, that witness was not against the London Company, although he favoured the alternating system to the transformer. His objection was to the connection between London and Deptford by their mains, but everything else he admitted to be workable. His objection related to the question of insulation and earthing, and he said the difficulties he anticipated were in connection with the insulation of joints, and with the disturbance of the electric and telegraph wires. But the London Company were willing to meet all the objections of the Post Office, and experiments were now going on with that object. The most important admission was that a cable could be made which would convey the current from Deptford to London, which would get rid of the Post Office objections, and ensure the safety of the public. Dr. Hopkinson admitted, dealing with the question of electrostatic induction, that there would be no difficulty with regard to the telegraph and telephone wires, if they were properly arranged. He would not recommend any rearrangement of those wires, but a proper arrangement of the electrical conductors, so that it would be quite unnecessary to disturb the telegraph and telephone lines in any way whatever. Sir William Thomson had given similar evidence, and said that he did not anticipate any of the difficulties referred to. Coming to the question of short circuiting, and the probabilities of a "flare-up" resulting from a breakdown referred to by Mr. Crompton in his evidence, that witness had admitted in cross-examination that the accident of this kind he once saw might have been the fault of the fuse, and that Mr. Ferranti would no doubt design a proper fuse. He thought that since Mr. Crompton put the process of the restitution of the light after a breakdown at half a minute only, and Mr. Swinburne at two or three seconds by the London system, he (Mr. Pember) thought that they could afford to ridicule all the silly talk about panics in theatres and such places. That difficulty had been spoken of in connection with the working of transformers, but it had been overcome long ago. The objection as to the dangers of transformers in private houses was answered by Mr. Heaphy, of the Phœnix Fire Office, who said there was no danger at all. After dealing with the agreement between the Strand District Board of Works and the Metropolitan Company, which he characterised as being contrary to public policy and the spirit of the Acts of 1886 and 1888, the learned counsel said that he did not think there was anything in the attitude of the local authorities which would prevent the orders being given *sub modo*, leaving to the Board of Trade the decision of details afterwards. He concluded by thanking Major Marindin for the patient and able manner in which he had conducted the enquiry.

Major Marindin, who said that it would be his duty to prepare without delay his report to the Board of Trade, briefly returned thanks, which closed the enquiry.

COMPANIES' MEETINGS.

SUBMARINE CABLES TRUST.

The eighteenth ordinary annual meeting of the certificate-holders in the Submarine Cables Trust was held on Friday last at the offices, Winchester-house, Old Broad-street.

Sir John Pender presided, and, in moving the adoption of the report, said the revenue for 1888 was £17,948, as against £19,018 in the past financial year. As mentioned at the last meeting, the certificate-holders for the two previous years received payment of their coupons at the rate of 4½ per cent., while for the year ended April last they had a return of 5⅝ per cent. They had not been disappointed with the estimate of revenue for the current year. Their coupons were cumulative, and were influenced by the success or otherwise of the respective companies in which they held stock. The active competition in the Transatlantic cable traffic had in the past resulted in the returns of the companies being small, which, in turn, had affected the trust. But things were now more settled in the telegraph world, and he thought they might look confidently forward to better times. Intimately connected, as he was, with the various telegraph companies, he believed their present prospects were favourable. With an improving trade, there had been an improved traffic, and there had of late been a marked increase in the returns. They had a large investment in the Anglo-American cable companies, and it was satisfactory to know that the Transatlantic traffic was likely to grow at the shilling rate. They expected that, if things turned out well, they would receive a return of £3. 17s. per cent. upon their investment.

The **Marquis of Tweeddale** seconded the motion, which was agreed to unanimously.

THE SUBMARINE TELEGRAPH COMPANY.

An extraordinary general meeting of the Submarine Telegraph Company between Great Britain and the Continent of Europe Limited, was held on Tuesday at the offices, Throgmorton-avenue, E.C.

Sir J. Goldsmid, M.P., who presided, stated that the shareholders would, no doubt, have been surprised at being summoned to another meeting, but the reason was very simple. Theirs was a chartered company, and the proceedings for a chartered company were not exactly the same as for a company established under the ordinary company law. They had thought, if they passed the resolution suitable for a chartered company to pass appointing liquidators and authorising a liquidation, that that would be sufficient, but as their Company was also registered under the Companies Clauses Act, the solicitor to the Post Office was of opinion that it was desirable that the resolution should be passed under that Act in addition to the resolution they had passed as a chartered company. He concluded by proposing a resolution winding up the Company voluntarily under the Companies Acts, 1862 and 1867, and appointing Sir J. Goldsmid (the chairman of the Company), the Hon. Henry R. Brand (a director), and Mr. S. M'Donnell Clare (the secretary) the liquidators.

The **Hon. Ashley Ponsonby** seconded the motion.

The **Chairman**, continuing, stated that they were proceeding satisfactorily with the liquidation. They had arranged with the Government for a sale of the cables at a price—an inadequate price; and they had also arranged for the sale of the house in which they were then assembled, and for the disposal of their steamer; and, in fact, of all their property. The Déolen cable, which had belonged jointly to the Company and the Paris and New York Company, would in future belong absolutely to the latter, who would pay the Submarine Company half price, as was originally arranged in the agreement which

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had been entered into between them. Practically, the only thing they had to settle now was as to what was to be done with the Salcombe cable; but that was a matter which would require still further negotiation and consideration. He had every hope that in the course of a fortnight, or at the outside three weeks, they would return a very substantial part of the capital to the shareholders, and they hoped that in the course of three months the liquidation would be completed. They had probably seen the very heated discussion which took place in the House of Commons as to the price the Government would pay them and the amount they had awarded as compensation to the employés of the Company whom they did not take over. He did not think it was desirable that he should discuss the proceedings of the House of Commons. The resolution having been put and carried, the Chairman stated that the meeting to confirm it would be held on the 19th prox. He added that he did not think it necessary to put the other resolutions which were passed at the last meeting, although it was announced that that would be done. It might be advisable to pass the following one: "That the liquidators be empowered to negotiate and sell, at a price to be fixed by valuation, or otherwise, the Salcombe and Déolen cables, belonging partly to the Company and partly to the Société Carmichael et Cie."

The **Hon. A. Ponsonby** seconded the motion, which was adopted.

Mr. Russell Griffiths thought it would be advisable for the other resolutions, of which notice had been given, to be put, which was done, and they were carried after a short discussion.

The **Chairman** afterwards proposed the resolution authorising the liquidators to supplement the money which the Government had agreed to pay to the employés in England of the companies not taken into the service of the Government by a further sum not exceeding £500.

The **Hon. A. Ponsonby** seconded the resolution, which was carried unanimously.

The **Chairman** stated that they had now passed all the resolutions except the one authorising the Government to work the cables from April 1. As the Government had worked them from that date, he thought it unnecessary to pass a resolution authorising them to do so.

Mr. King and **Mr. Pawle** afterwards addressed the meeting, the former complaining of the action of the Government towards the Company, and the latter asking for information to account for the difference between the £330,000 of capital expended, and the £100,000 which the Company would receive.

The **Chairman**, in reply, said he could agree only with some of the remarks that had been made. He agreed that they were getting a very poor price for their property, but he could not agree that the Government ought to pay them the price of new cables for old ones. Those who had paid a high premium for their shares would not get such premium back, but many who had paid a high premium for their shares had been receiving large dividends, and if they had acted wisely they had put by a considerable proportion of their dividends as a sinking fund for their capital. He agreed that the Company had not been handsomely treated, but he could assure the shareholders that the Directors had done their utmost to obtain the best possible terms. They must accept the position, which was disagreeable, but which might have been worse had not the shareholders and the Directors been a little provident.

The proceedings then terminated.

CITY NOTES.

Brazilian Submarine Telegraph Company.—The receipts for the week ended May 24 amounted to £5,313.

Western and Brazilian Submarine Telegraph Company.—The traffic receipts for the past week were £3,813.

Business Note.—Messrs. W. H. Wilcox and Co., of 36, Southwark-street, inform us that having purchased the premises, business, goodwill, and stock of W. Goodwin and Co., 36, Primrose-street, leather machine band, etc., manufacturers, they are now in a position to give special attention to this department.

Spanish National Submarine Telegraph Company, Limited.—The numbers are announced of 72 bonds, amounting to £7,200 of the Spanish National Submarine Telegraph Company, Limited, 6 per cent. mortgage debentures to be paid off at par at the offices of the Company, 106, Cannon-street, E.C., on and after June 29 next.

Liverpool Central Hydro-Electric and Massage Company.—This Company has been registered by Hughes Quilliam, 6, Parker-street, Liverpool, with a capital of £500, in £1 shares. Object: to acquire the Russian, Turkish, and Electric Baths, situate at 3 and 5, Cases-street, Liverpool. Registered without articles of association, and consequently the regulations of table A in the first schedule of the Companies' Act, 1862, apply.

PROVISIONAL PATENTS, 1889.

MAY 20.

8360. **Improvements in apparatus relating to telephone systems.** Fred. A. Holcomb, 18, Buckingham-street, Strand, London. (Complete specification.)

MAY 21.

8390. **Improvements in electric motors.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

8400. **An improvement in electric bells.** John Megson Porter, 34, Ebor-place, Leeds.

8451. **Improvements in conduits for electric light and other wires.** George Gollop, 70, Chancery-lane, London.

8453. **Improvements in regulating electric currents.** William Morris Mordey, 46, Lincoln's-inn-fields, London.

8456. **Improvements in portable electric safety lamps.** Lars Bristöl, 70, Chancery-lane, London.

8459. **Improvements in dynamo electric machines and electric motors.** Thomas Leopold Willson, 55 and 56, Chancery-lane, Middlesex.

8460. **Improvements in coating and protecting wires for electrical, telephonic, and other analogous purposes, also applicable in the manufacture of tubing.** George France and Eli Holroyd, 8, Quality-court, London.

8468. **Improvements in tramcars, locomotives, or other vehicles driven by electricity.** Thomas Drake Hollick, 35, Southampton-buildings, London.

MAY 22.

8493. **Improvements in automatic cut-outs for electric circuits.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

8528. **Transmission of power by alternate electric currents and apparatus therefor.** John Hopkinson, 47, Lincoln's-inn-fields, London.

MAY 23.

8557. **Improvements in or relating to meters or instruments for measuring currents of electricity.** Mark Parker, 323, High Holborn, Middlesex.

8559. **Improvements in securing telegraph wires to insulators.** William Osberne and James Salter Scales, 23, St. Stephen's-street, Tonbridge, Kent.

8569. **Insulating and suspending wires, cables and conductors for electrical currents.** Wallace James Lambert Sandy, 36, Maxted-road, East Dulwich, London.

8588. **Improvements in alternating current dynamos and motors.** James Swinburne, 49, Queen's-road, Wimbledon.

8606. **An improved form of secondary battery for the use of miners and the like, and lamp mount for same.** Mark Bailey and John Warner, 21, Finsbury-pavement, London.

8614. **Improvements in electric lampholders or coupling pieces for use in series circuits.** Albert Augustus Goldston, 4, South-street, Finsbury, London.

8619. **An improved electrical alarm for audibly indicating and announcing the varying water levels of steam boilers and the like.** Andrew Siegmann, 20, High Holborn, London. (Complete specification.)

MAY 24.

8631. **An improved portable electric lamp and battery.** Robert Thompson and Horace Seymour Pyne, 27, King-street, Liverpool.

8657. **Improved methods and appliances for conducting and distributing electric currents.** Edward Brailsford Bright, Francis William Engelbach, and John Brailsford Bright, 31, Golden-square, Regent-street.

8674. **Improvements in connection with electrical tramways or railways.** John Hopkinson, 47, Lincoln's-inn-fields, London.

8692. **Improvements in multiple switchboard systems for telephonic exchanges, and wire bands to be used therein.** John Edward Kingsbury, 24, Southampton-buildings, London. (The Western Electric Company, United States.)

SPECIFICATIONS PUBLISHED

1888.

7523. **Electric lighting.** Houghton. 8d.
8765. **Electric lamps.** Rowbotham and Fox. 8d.
9405. **Charging electrical accumulators.** Yorke. 6d.
9487. **Electrical instruments.** Rawson and White. 8d.
9854. **Secondary batteries.** Bristol. 8d.
18091. **Electro-motors.** Aldred. 8d.

1889.

2406. **Electric arc lamps.** Roper. 6d.
3350. **Measuring electric currents.** Sir C. S. Forbes. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	19½
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply ...	5	3¾
......	...	Swan United	3½	2
12 July	12/0	Telegraph Construction ...	12	42½
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15½

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NOTES.

Overhead Pole.—The city of Mexico is following the example of New York, and proposes to remove all electric wires from its streets.

New Journal.—We have received a copy of a new Spanish journal entitled *El Telegrafista Espanol*, dealing with matters electrical, published in Madrid.

The London Electric Corporation.—Mr. James Staats Forbes has joined the board of the London Electric Supply Corporation, Limited, as deputy chairman.

Dock Lighting at Belfast.—Messrs. Crompton and Co. have secured a large order from Messrs. Harland and Wolff, shipbuilders, of Belfast, for arc lamps and dynamos.

Execution by Electricity.—The American Government have purchased three sets of dynamos and apparatus for execution of criminals, to be placed at Sing Sing, Auburn, and Clinton prisons.

Fluted Carbons.—M. F. Carré, the well-known maker of carbons in France, points out that fluted carbons claimed as first used by Sir James Douglass, were patented by him as long ago as November, 1881.

Incandescent Lamp Patents.—Is it a fact, as rumoured in Paris, that the Edison Company have lost an action lately instituted against the Khotinsky Company for infringement of incandescent patent rights ?

Frankfort.—The river harbour at Frankfort-on-Main is now lighted by 15 1,000-c.p. arc lamps and 73 incandescents on the transformer system, supplied by the "Helios" Company, of Cologne and Ehrenfeld.

American Engineers.—A large number of American engineers, in all about 250, arrived in Liverpool this week on board the "City of Richmond" and the "City of New York," on their way to London and the Paris Exhibition.

Italy.—It is stated that the towns of Florence and Pistola have granted concessions for the establishment of central electric light stations for public and private lighting to the Société Belge d'Electricité, represented by M. Léon Gerard, of Brussels.

The Seel Lamp.—A limited company has just been formed in Belgium for the manufacture of the Seel incandescent lamps, with a capital of 5,000,000f., under the name of the "Société Anonyme Belge pour la Fabrication des Lamps Electrique à Incandescence."

Republic of Columbia.—Electric lights are needed in the Republic of Columbia, the Government being in favour of extension in this direction. Special concessions will be made to electric light companies for the period of twenty-five years for lighting the different cities.

Proposed Submarine Cable.—The Spanish Government will receive up till the 20th June next, at the offices of the Minister of Colonies, Madrid, tenders for the laying of three submarine cables between the islands of Luzen, Parray, Negus, and Cuca, a total length of about 200 miles.

Leeds.—The Leeds Corporation seem inclined to take up the question of electric lighting in a practical manner. The borough engineer of Leeds, at the last meeting suggested the expenditure of £60,000 for a central station. It was decided to print the report, and adjourn the meeting to June 12th for discussion.

West Coast Cables.—The Eastern Telegraph Company notifies the opening for traffic of the Eastern and South African Company's new West Coast cable to Cape Town, thus affording an alternative means of telegraphic communication with South Africa. Telegrams can be sent by the East or West Coast cable routes at the same tariff.

Railway Lighting.—The Chesapeake and Ohio Railway have just received some new cars from the Pullman Company. They are fitted throughout with electric light; the Eickmeyer dynamo, Brotherhood engines, and the Electrical Accumulator Company's storage batteries are used. The whole of the passenger trains on this line will be lighted by electric light.

Mulheim Cables.—We have received a pamphlet, with reference to the goods of Messrs. Felten and Guilleaume, wire and cable manufacturers, of Mülheim-on-the-Rhine, near Cologne. The pamphlet is issued by Messrs. W. F. Dennis and Co., 11, Billiter-street, E.C., and is indicative of the position the firm are now taking in this country in the supply of wires and copper cables.

Dinner to Prof Elihu Thomson.—Prof. Elihu Thomson, of Thomson-Houston world-wide celebrity, is expected in England this month, and the Laing, Wharton, and Down Construction Syndicate, Limited, intend to welcome him on his arrival by giving him a reception and dinner at The Ship, Greenwich, where a number of English electrical celebrities are invited to welcome their American *confrère*.

Denmark.—Copenhagen is one of the few towns on the Continent possessing its own gas works, and will probably soon possess its own electric light station. One of the chief engineers has recently been on tour to visit the principal large central stations in London and Germany, and plans are being prepared for a station for 10,000 lights, with capacity for doubling the output when required. Stockholm and Christiania are also moving in the matter of central stations.

The Edison Patents.—The law case between the Sawyer Man and the Edison companies has recently been brought before the courts at Pittsburg, and, according to the New York *Tribune*, Edison's counsel now abandons the claim for fibrous materials for incandescent lamps, saying that they were used by many inventors since the days of Sir Humphry Davy. It seems rather peculiar that the very facts relied upon in English courts are not claimed by Edison in America.

Electric Mining Stamps.—Despatches from Auckland states that gold has been found on the Nenthorn reefs, and the erection of a crushing battery with electricity as the motive-power is advised by Mr. E. Foord, who has visited the district. One of the samples of quartz is from a newly-discovered reef about a mile from any other line on the field. It is a very rich specimen, being thickly studded with gold. A company is being formed among the various holders of leases to arrange for the erection of the crushing machinery.

Double Lamps.—Another sweeping claim is being made in America. The Brush Electric Company, of Cleveland, are notifying local authorities not to use double lamps in lighting the streets unless manufactured by the Brush Company, as they claim that all double carbon lamps were infringements on patents granted to C. F. Brush. The company state that they intend to institute proceedings against all manufacturers of double lamps, as well as

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against all those using a differential magnet in their lamps, either double or single.

The Baxter Motor.—It was intended to exploit the Baxter motor in England if we may judge from the following, but the intention has had to be dropped: Angus Cameron and Thomas Gemmell, of London, and Malcolm Sinclair, of Cumberland, Maryland, U.S., have sued the Baxter Company for fifty thousand dollars for breach of contract. A syndicate was to be organised in London, but the negotiations fell through on account of complications in the business of the Baxter Company. Their business is evidently still more complicated now.

Paris Jury.—The following are the members of the jury of the electrical section for the Paris Exhibition: MM. Fontaine (Société Gramme), Fribourg (Government telegraphs), Huet (sous-directeur of works of Paris), Mascart (membre de l'Institut), Postel-Vinay (engineer), Potier (professor at l'Ecole Nationale), Sciama (director of the firm of Breguet), Sébert (colonel, director Marine laboratory), Trotin (post and telegraph office). Supplementary members: MM. Jousselin (P.L.M. Railway), Rau (Edison Company), Sautter (Sautter-Lemonnier and Co.).

The New Telephone Company.—The business of this company has come to an end owing to an action which had been brought against them by the United Telephone Company, in which an injunction had been granted restraining the New Telephone Company from manufacturing telephones, on the ground that they were infringing the patents of the United Company. Under these circumstances resolutions had been passed by the shareholders for a voluntary winding-up on Monday last, and the usual supervision order was made upon the petition of the company.

The Waterhouse System.—Since the acquisition of the Waterhouse arc lighting system by the Westinghouse Electric Company, of Pittsburgh, according to American advices, great progress in the introduction of this system has been made. The works have recently been removed from Hartford to Pittsburgh, and the Westinghouse Company have just issued a second list of installations, comprising 800 lamps, carried out during the past six months. We note, also, that they have just secured a contract for installing 500 Waterhouse arc lamps of this system for lighting the streets of Philadelphia.

H.M.S. "Marathon."—The trial of the engines of H.M.S. "Marathon" took place at Portsmouth last week. The ship has been furnished throughout with the latest improvements. Voice-tubes and electric bells connect the conning tower and bridges with the captain's and chief engineer's berths, engine-room, and stokeholds. The ship is also fitted with electric steering gear, electric counters, and electric revolution indicators; while the electric light, which includes three powerful search lights, is supplied from two duplicate engines, one being stationed in the engine-room and the other in the dynamo-room.

Holiday Rejoicings by Telephone.—A lady editor in Philadelphia who takes her press news over the long distance telephone from New York in order to hear more distinctly, wears a metal cap attached to a receiver, which presses close to her ear. During the recent naval pageant at New York to welcome the arrival of the President, she distinctly heard the whistles of the steamers, the roar of the artillery, and the bells of Trinity Church. On the next day the strains of martial music and the hurrahs of the assembled crowds were plainly borne to her ears, the first time probably that outside sounds of this nature have been distinctly heard over some hundreds of miles.

Johannesburg.—In the upper Southern African goldfields, towns are springing up in marvellous fashion we are accustomed to connect with America only. Johannesburg is one of the most prosperous of these, and is now a large and well-developed town with many thousands of inhabitants, where a few years ago there was little but a few squatters. Squares and streets with large and fine buildings and offices have sprung up, and the lighting of these is at present a matter of interest. The Johannesburg Gas Company are putting up large gas works, designed and constructed in England, and electric lighting is also likely to be in request. It is probable that an active agency, both for electric lighting and also for electric transmission of power, would result in good business from the new goldfield towns of Africa.

The Spanish Exhibition.—The electric lighting of the exhibition at Earl's Court, the Spanish Exhibition, is this year on a low-tension system, the Gulcher Company having secured the contract. The machinery is in the same situation as last year, and already 185 arc lamps are lighted from this dynamo-room, as well as some 200 incandescents, which will be soon considerably increased in number. Eight Gulcher dynamos of various sizes are now installed, and others are to be added. The engines are 30 h.p. nominal semi-portable type, working up to about 100 h.p. each, two of them being Marshall's engines, and one Ruston, Proctor, and Co.'s; another of the latter is to be fixed shortly. The potential of the circuits is 65 volts, the arc lamps being run in parallel on the Gulcher system.

Train Lighting.—As the electric lighting of trains is now in a fair way to be widely adopted on many lines, an economic hint from previous experience of gas may not be out of place. In a most interesting book upon "The Railways of England," by W. M. Acworth, it is mentioned in a footnote that the engineer of the Paris, Lyons, and Mediterranean Railway has stated that he has economised £4,000 a year by connecting the taps of the gasjets with the night caps of the carriage lamps, so that when the cap is drawn over the glass the gas is turned down to a mere glimmer. This is a large sum, and it is hardly likely that so much would be saved by turning down the electric light (it should not be turned quite out), but means for doing so on the night trains should not be omitted, both on this score and on that of comfort to the eyes of sleepers. In the same book it is mentioned that the comparative cost of oil, gas, and electricity is as 1 : 1¼ : 1½.

Magnetic Separation of Ore.—Mr. Josiah T. Smith, in his address as president of the British Iron Trade Association, at the Westminster Palace Hotel, referred to the fact that magnetic separation has been resorted to in some parts of the American continent, with a view to eliminating from impure ores the deleterious ingredients that unfit them for the production of high-class metal. This, he said, would be another factor in fixing the probabilities of the future of the iron ore trade that must not be lost sight of. Whether the magnetic separation of iron from the materials with which it is found associated in nature is at present an assured economic success or not, so much has been actually done in this direction by Wenström and others as to justify the hope that we shall see applied to ores *per se* as effectual treatment with a view to getting rid of phospherus and other metalloids as we have already seen

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applied to the treatment of impure iron by the basic process.

Charing Cross.—The Works Committee of the St. Martin-in-the Fields Vestry on May 30 reported on a letter from the County Council addressed to the London Electric Supply Corporation, declining, in the absence of any statutory powers possessed by the corporation, to grant the use of subways for the purpose of laying electric cables. There was also a letter from the corporation applying for permission to lay two 4in. pipes under the roadways from Peabody-buildings at the corner of Chandos-street and St. Martin's-place, across Charing-cross-road, and along Green-street to No. 21 therein. The committee recommended that the application be granted. Some objection was raised by members living in the district on the score of inconvenience to traffic, but it was remarked that the application was only a small matter—only two pipes, and not a subway, and there would be no pulling up of the streets—and that the time had come for electricity to supersede gas, which was inadequate. The application was then granted, the time for commencing the work to be fixed by the surveyor.

The King's College Engineering Society.—On Thursday last Mr. Chas. Mittelhausen read his presidential address to the Engineering Society at King's College, Strand, on a few recent engineering advances. The author showed experimentally on a small scale how sewage could be precipitated electrically by means of iron electrodes, and indicated how this long-known scientific fact had been turned to practical account in the Webster process. The series system of electrical traction was then described, and the working shown by means of a model. Speaking on the advantages of photography for engineers, Grimston's new patent shutter was mentioned on account both of the simplicity and accessibility of its mechanism. The author also referred to Messrs. Siemens Bros.' new Morse instrument, whilst with reference to the question of national defence some of the newest methods of operating submarine mines was explained. In the civil engineering world the chief features of the Forth and Lansdowne bridges were described, and the address terminated with some remarks upon the usefulness of the Eiffel Tower. A cordial vote of thanks was given to Mr. Mittelhausen for his interesting paper.

Chelmsford.—At a meeting of the Chelmsford Town Council on May 29, the Lighting Committee reported that the draft contract with Messrs. Crompton and Co. had been finally settled, and they offered as sureties for the due performance of the contract Viscount Torrington and Sir Charles Grant. The committee recommended that these gentlemen be accepted. The committee further recommended certain slight alterations in the scheme. In reply to Alderman Dutton, the Mayor said that if the light failed the fine would be £500. The motion for approval and sealing of the contract was carried. Alderman Gray said he thought the thanks of the Council were due to the Lighting Committee for the immense trouble they had taken in the matter. They hoped the lighting would be a success, but if it was not it would be no fault of the committee. A discussion took place as to whether a license should be taken out, and Councillor Albright said he should like to have an opinion from the Council as to whether they intended to proceed in the matter. His firm (Messrs. Crompton and Co.) had taken all the preliminary steps to procure a license, but if the Council intended to get one themselves Messrs. Crompton would of course not proceed with their application The question was referred to the Lighting Committee.

Central Lighting in Birmingham.—The difficulties attending the negotiations for a central station in Birmingham appear to have been satisfactorily settled, and it is anticipated that the provisional order promoted by Messrs. Chamberlain and Hookham will now be granted. The final form, as settled by the promoters in consultation with the Board of Trade and the Public Works Committee, limits the provisional order to a restricted area of the city, composed principally of Market Hall Ward. The promoters will be required to form a capital of £50,000. On some disputed points of procedure, including certain protective clauses usually required by the Corporation to be inserted in local Acts of Parliament, Messrs. Chamberlain and Hookham are willing to submit to the usual conditions. With regard to certain objections made to clauses in their own and in the London and other provisional orders, the promoters agree to accept the general ruling of the Board of Trade. The stipulated company will be formed immediately on the confirmation of the provisional order. Messrs. Chamberlain and Hookham have, we are informed, served the necessary notice upon the Town Council to enable them to apply next session for a further provisional order for a more extended area than that for which the present arrangement deals with.

Mayfield's Catalogue.—We have received a copy of the catalogue of Messrs. Mayfield and Co., Limited, of 41, Queen Victoria street. This firm (who, by-the-way, we note, have just altered their title from that of Mayfield, Cobb, and Co.) keep in stock and manufacture a large number of electrical instruments and apparatus, batteries, bells, indicators, lamps, and measuring instruments. We note their burglar alarm contact, and their double-lock indicator movement, in which the flag works in any position, both useful inventions. Also a large number of scientific and teaching apparatus, which the firm manufacture themselves. The Wimshurst machine is a speciality of this firm illustrated in the catalogue. Several of the larger size of Wimshurst machines have lately been supplied to the Deptford station for testing the high-tension dynamos, and to Messrs. Felten and Guilleaume, who are manufacturing the Ferranti cables for testing insulation. Another of these large machines, giving a 13in. spark, will be on exhibition at Paris. Mr. Mayfield, who for a long time was manager for Mr. J. W. Swan, at Newcastle, has a number of interesting instruments and fittings at his premises, and turns out a considerable amount of work in the manufacture of electrical requirements. His partner, Mr. Todman, has patented sundry ingenious instruments and improvements, and we note among the proprietors of the limited company into which the concern has been formed, the names of Sir Charles Forbes and Mr. Ince.

Telpher Lines and Progress.—The United Electrical Engineering Company have two further telpher lines under contract, one of 10 miles and the other of six miles long. The appreciation of this method of electric traction is spreading, and Mr. A. R. Bennett's recent remarks before the East of Scotland Engineering Association have served to point out that particularly in Scotland, as in other thinly populated hilly districts, light overhead telpher lines would prove profitable where ordinary railways, or even light tramways, would not pay. It is also a very great point in favour of the adoption of overhead lines for many situa-

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tions, that no compulsory powers for buying land would be needed from Parliament; the immense outlay otherwise necessary for land would be also saved, and the line itself would be cheaper in construction than other lines. It is therefore no great wonder, now that the practical working details have been settled, that indications are forthcoming of the rapid extension of the telpher system, throughout Great Britain, as feeders to the main railway lines. From the colonies also we should expect good orders will be the result. The United Electrical Engineering Company appear to be laying themselves out for increased work in anticipation of telpher business. In other branches also, we are pleased to note, they are active, and some very commendable little pamphlets are either issued or in preparation to give full and accurate information in an intelligible style to proposing customers. One of these is on the above-mentioned "Telpher System of Cheap Transit," and another on "Machine Driving by Electricity" will prove useful to give suggestive information to factory proprietors. Electric lighting commercially considered comes into the scope of another of these pamphlets, and a separate one, in preparation, on electric lighting as applied to decorative art, deals with another phase of the United Company's operations.

The Sprague System.—Considerable surprise is likely to be expressed in connection with the Electric Works Corporation combination at the sudden prominence given to the Sprague motor in England, as little, if any, work has been done over here, although large numbers of electric railways are using Sprague motors in America. There, however, the work is nearly all upon the overhead system of conductors, a system practically impossible of introduction in English towns; and the present connection of Sprague with what will practically be an accumulator manufacturing concern lends some confirmation to what has been hinted, we do not know with what truth, that, in fact, Sprague is rather tired of overhead conductor systems, not finding in practice that simplicity in cars atones for the complication in the conductors and other apparatus. It certainly appears the fact the electric traction for cars in England seems to have a decided leaning towards the employment of storage cars in preference to conductor systems for streets; and a very large rush of business in this direction may be confidently expected, for English local authorities would strongly object to the long strings of posts and wires familiar to us in illustrations of the American street-railway practice. Storage batteries have now proved themselves capable of commercial employment for this purpose, and we learn that although by far the larger number of electric tramways in the States use the overhead system, nevertheless there are now upwards of 40 electric railways using or proposing to use storage batteries in the States. Many of these are naturally promoted by persons interested in the manufacture or supply of accumulators, while others are constructed by companies or local authorities after discussing the merits of both systems. It would be interesting to learn, after the experience, in some cases of a year or two's working, how far such pioneers of overhead systems as the Sprague Company have realised in practice the advantages of their systems, or how far their present ideas have been influenced by the comparatively later advances of the storage car.

The Telephone Amalgamation.—In the House of Commons on Monday Mr. R. Chamberlain asked the Postmaster-General whether his attention had been called to the tactics by which the financial group now commanding the telephone system of the kingdom had met his refusal to grant a license to the Amalgamated Company originally projected; whether his attention had been directed to the amount of capital to be created under the new scheme, and to the high charges to the public that would have to be maintained in consequence, and to the proportionately enhanced price that would be demanded should the nation ever decide to purchase; and whether under these circumstances he will at once avail himself of the right reserved under the agreement with the telephone companies, and "establish, extend, maintain, and work" a telephone system, such as would gradually bring the advantages of this invention within reach of the masses of the people. He wished to explain that the clerks had omitted a vigorous adjective which he had inserted before the word "capital." What he wished to call attention to was that this capital was not represented by any estate in the form of plant, buildings, wires, or instruments. It was a paper capital, and not a real capital. Mr. Raikes said, in reply to the hon. member, I have to state that I am aware of the proceedings of the telephone companies, and that the whole question of the telephonic service of the country is engaging my serious attention. I am not at all sorry that this question has been asked, as it may serve to direct public attention to a matter of extreme gravity, with regard to which expressions of public opinion may materially strengthen my department in protecting the public interest. The Postmaster-General, through the secretary of the Post Office, has written to the United Telephone Company to acquaint them, for the information of the directors and shareholders, that the amalgamation of the companies was not contemplated when the licenses were issued, and that any assurances, outside the licenses, which the companies may conceive themselves to have received from the then Postmaster-General cannot be regarded as applicable to the state of things likely to result from the proposed amalgamation.

Steam Trams Objected To.—A very good instance of the attitude which the public hold towards the steam trams was given on Tuesday, when Sir Michael Hicks-Beach (accompanied by Mr. Calcraft, C.B., Mr. Courtenay Boyle, C.B., and Sir T. W. P. Blomefield) received a deputation from the Wood Green Local Board with reference to the use of steam by the North London Tramways Company. Mr. Littler, Q.C., chairman of the Local Board, said the Local Board were not in existence when the company's Act was passed, or they would have opposed the granting of steam powers. They were constantly receiving complaints of the annoyance to the ratepayers, and on investigation they found that the nuisance was inseparable from the use of steam. Rateable values were seriously diminishing, and the practice was dangerous to the public. Accidents were occurring daily; only last Saturday an omnibus was overturned, and that morning it was announced that one of the passengers had died in consequence. An arbitrator was now enquiring into the question of terms, and the deputation asked that the question of whether steam should be used should also be referred to arbitration. They did not desire to stop the tramways, but the feelings against the use of steam was universal, and the road, which was just beyond the Parliamentary area, was as bad a road for steam as any of the metropolitan roads. Mr. Melluish, chairman of the South Hornsey Local Board, confirmed the statement made by Mr. Littler. Sir

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Michael Hicks-Beach, however, could not see his way to interfere. He suggested that the courts were open to the Local Board, and this would be the proper procedure, rather than ask him to do anything which would be straining the power vested in the Board of Trade. We should imagine the trouble the North London Tramways Company are having with their steam trams should urge them, more particularly at this present juncture, to consider the adoption of electric traction, and not only from the absence of annoyance, but also upon the question of cost of running. It is suggestive also to compare the words used by Mr. Littler, that with the use of steam "rateable values were seriously diminishing," with those given with reference to the City of Richmond, Virginia, where it was pointed out that the introduction of the electric tramways had already increased the value of the surrounding properties. The crusade against steam in the streets has evidently commenced in earnest.

Lines of Electrical Induction.—In the *Scientific American*, R. W. Chapman, of the University of Adelaide, South Australia, gives an account of some very pretty experiments which may be made to show lines of electrical induction between two electrified bodies, by the use of the fine white needle-like crystals of sulphate of quinine suspended in a good insulating liquid, such as pure turpentine. To perform the experiments, he says, take a flat glass dish, and pour in turpentine to the depth of about a quarter of an inch, sprinkle this with sulphate of quinine evenly distributed till the turpentine assumes a milky appearance. If now a brass ball connected by a chain with an electrical machine be placed at one end of the vessel, and another connected with earth at the other end of the vessel, on working the machine the crystals of quinine will become polarised, and take up their positions end on end, forming very distinct curved lines between the balls in exactly the same way as iron filings form in lines of magnetic induction when sprinkled over a magnet. The symmetrical lines of white crystals when shown up by a dark background look extremely beautiful. We have here the basis for a set of experiments which may be diversified to an almost unlimited extent by varying the number and shapes of the electrified bodies placed in the turpentine. The fact that there is no electrical force within a hollow conductor may be very prettily shown by connecting both of the balls in the above experiment with the machine and placing in between them a large metal ring connected with earth. The curved lines are then very distinctly shown running from each ball to the ring, but within the ring the turpentine remains in the uniformly cloudy state in which it was initially, the crystals showing no disposition to place themselves end on end. The difference in the appearance of the quinine particles outside and inside the ring is very striking. If now a small third ball be connected with the machine and placed in the centre of the metal ring, the appearance of the turpentine within the ring is entirely changed, and the crystals form in straight radial lines from the centre to the circumference. By multiplying the number of the electrified balls, charging some positively and others negatively, the resulting lines of induction may be made very complicated, but, provided that there is a fair space between the balls, the lines are always distinctly and clearly mapped out by the crystals. It is an easy matter to obtain some very beautiful figures by symmetrical distribution of the electrified bodies. In making the experiments it is very necessary that the turpentine should be pure and dry, as a very slight amount of impurity is sufficient to destroy its powers as an insulating medium. Benzine will answer, and it possesses the additional advantage of not dissolving any of the quinine, while turpentine dissolves it to a slight extent, but its specific gravity is so small that the crystals fall to the bottom of the vessel almost at once, and adhere to it, so that they will not easily take up the lines unless the experimenter be sufficiently quick to electrify the balls before the particles reach the bottom. On the whole, turpentine I have found to give the most satisfactory results. After the crystals have once been electrified inductively in this way, they appear to take up the lines much more easily a second time. It seems as though the molecules do not recover altogether from the effects of the electric strain.

Electric Door Openers for Asylums.—Some few weeks ago we alluded to the electric door openers which had been fitted at the Milwaukee Asylum for Insane, Wisconsin. The superintendent, M. J. White, M.D., has recently described in detail his apparatus, which his committee, being strongly alive to the necessity for neglecting no practical means of safety, have granted him powers to fit to the doors. The lock is set into the door-jamb, and operates in connection with the bolt of the mechanical lock, which is of course situated in the door. In this manner the bolt of the mechanical lock is slid behind the bolt of the electrical apparatus, and held there securely by it until the current is turned on, when the electrical bolt recedes into the lock and releases the mechanical bolt. At the same instant a mechanical device, situate in the lock, in the form of a powerful spring push, and which is up to the highest state of tension when the door is locked, is released, and acting upon a small brass plate fastened to the door, serves to throw it a distance of three feet. The door is thrown open with its bolt shot and immovable, and cannot be closed again except by means of the key, as the electric bolt is immovable save when influenced by the current. This forms an advantage in preventing viciously inclined patients from securing themselves in their rooms or inveigling attendants therein and imprisoning them, as might happen in case a spring latch were used, as was suggested at one time. The device has the appearance of an ordinary lock, and nothing in connection with the system is objectionable as tending to suggest disagreeable associations, as the wires are all concealed under the mouldings of the door frames, and carried through the floor to the ceiling below in the basement, and along it to a locked cabinet containing the cells. At present the ten doors are operated by means of eight cells, the ordinary bell battery with sal ammoniac solution being used. A test of the apparatus is practically made every morning, as the patients are released in this way, and in case of any imperfect working the defect can be immediately traced and corrected, so as to ensure its efficiency in any event The push buttons are located in the attendants' rooms and are operated at that point, but in order to make assurance doubly sure, the wires are to be carried to the superintendent's office and are to be controlled from that point also. It is intended also to have a separate button to operate the exit and fire-escape doors, which will be used solely in case of emergency. This arrangement will provide a perfectly free exit from the building as well as from the sleeping-rooms.

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ELECTRIC LIGHTING IN LONDON.

The Board of Trade enquiry recently held by Major Marindin was, amongst other things, for the purpose of investigating the nature of the systems of supply proposed by the various companies.

These were two in number, which may be referred to as the alternating-current system and the direct-current system.

Major Marindin, in his recommendations as to the provisional orders to be granted, has given by far the largest area to the companies adopting the alternating-current system.

It may therefore be advantageous to notice more particularly some of his findings as to this system and its rival, now practically ousted from London.

Speaking of the disadvantages of the alternating system, he says :

1. It necessitates great care and expense in insulation.
2. It involves some risk to life.
3. The main cannot be handled or connections made when the pressure is on.
4. The system cannot be efficiently utilised (a) for motive power, (b) for electric deposition, or other chemical uses such as charging accumulators.
5. The system depends entirely upon running machinery.
6. The engines and dynamos have to be kept in motion throughout the 24 hours.
7. The general efficiency must be low during 18 hours of every day on the average.
8. A serious accident in the generating station might stop the supply for a considerable time.
9. The measurement offers considerable difficulty, and with special reference to the London Electric Supply Corporation, he says—
10. That an accident, such as the bursting of one of the large steampipes, might have the effect of stopping the whole supply is certain.
11. The objection that the scheme of the London Electric Corporation is a gigantic experiment is no doubt in a certain sense true.

The only advantage found in its favour is that of "cost," an advantage that is immediately lost in the conditions imposed of duplicate stations and duplicate mains.

On the other hand, the only finding suggested against the direct system is that of cost.

But as this finding is said to be based on the evidence, and not on the conditions put upon the alternating companies, it is evident that even on the question of cost the result of the report is in the end favourable to the direct system.

The other findings in favour of the direct system are called *enormous advantages*, and thus described :

1. In the event of a total breakdown at the generating station supply can still be maintained for some hours.
2. It is not necessary to keep the machinery at the generating station in motion throughout the whole 24 hours.
3. The batteries provide a supply for the long hours when very little is required.
4. Applicability to the supply of motive power and other uses, besides light and heat.
5. Greater ease of measurement.
6. The regulation should be very good.
7. A battery current is less destructive to lamps.
8. From a consumer's point of view the supply made from accumulators *is the most* valuable.

And to make it clear that on the question of cost the evidence given was in favour of the direct supply, the following extracts are given from the evidence of witnesses *called in favour of the alternating system.*

Mr. A. Siemens.—Q. 3560. With regard to a united series of small stations, do you consider that to be one of the best solutions of lighting a town ?—Certainly, it is one of the best.

Q. 3568. From your experience, would not a small area be lighted as economically on a low-tension direct-current system as on the alternating-current system ?—Certainly, much cheaper.

Sir William Thomson.—Q. 3810. Assuming you have a very large area of supply, and a great number of lights to supply within that area, do not you consider the low-tension direct system more economical than an alternating system ?—If there is no point more than a quarter of a mile from the station, I should say so.

Q. 3811. Just about a quarter of a mile ?—I should say the direct system would be preferable.

For be it remembered that London is not a "scattered area," for which the alternating system may possibly be cheaper, but *a mass of densely populated small areas.* Thus the Board of Trade inspector, having the question properly left to him to report upon the systems, reports entirely in favour of the direct supply system.

And having, as it is submitted, most improperly left to him the question of provisional orders to be granted, treats with contempt the results found by himself, in order to exercise his evidently strong bias in favour of a particular company, and endeavours to salve his own conscience by the remark that "It may be predicted with tolerable certainty that whatever system proves itself to be best under all circumstances will eventually be adopted by all."

ELECTROLYSIS OF NICKEL SALTS.

BY ALEXANDER WATT.

(Continued from page 411.)

15. *Oxide of Nickel in Ammonia.*—A solution was prepared by digesting recently precipitated and moist hydrated oxide of nickel in strong liquid ammonia, and the resulting blue solution was afterwards moderately diluted with water. With the current from two small Daniell cells in series there was little or no metal deposited upon a brass cathode A third cell was therefore added, when a yellowish film of nickel formed upon both surfaces of a brass plate. There was no evolution of hydrogen at the cathode, but a copious liberation of gas at the anode, which electrode became coated with a brown-coloured film, and a green deposit also appeared on this plate at the surface just above the water-line. It thus appeared that two different substances had formed upon the positive electrode A green salt also formed in the solution, rendering it turbid.

16. *Nitrate of Nickel.*—A bath was prepared by dissolving nickel carbonate in one part nitric acid to two parts of water until a neutral solution was obtained. The resulting solution, after filtration, was electrolysed with the current from two Daniells in series, but no deposit of metal occurred. A third cell was then connected, but with a like result. No hydrogen was given off at the cathode, but a slight evolution of oxygen appeared at the positive electrode.

17. *Nitrates of Nickel and Ammonium.*—A solution of nitrate of ammonia was added, a little at a time, to the foregoing bath, and the same current employed, the object being to determine whether the ammonium salt would tend to assist the deposition of the metal. Such was not the case, however, for the cathode merely became discoloured, while a green deposit formed on its surface. In this case, as in the last, no hydrogen was liberated, but small bubbles of gas appeared at the anode.

18. *Sulphate of Nickel.*—A solution was prepared by dissolving one ounce of the salt in ten ounces of water, and the current from two cells at first tried ; but as the metal deposited but slowly, a third cell was put in series, when a clean brass plate readily became coated with nickel. The film, which was of a good colour, was not, however, so adherent as is the case with deposits from the double sulphates of nickel and ammonia.

19. *Ammonio-sulphate of Nickel.*—It was next determined to ascertain whether small and increasing additions of liquid ammonia to the sulphate solution would tend to increase the adhesion of the deposited metal and improve its character generally. The current from three cells, as before, was used, and a fresh plate immersed after each addition of the ammonia. When the first addition of ammonia had been given, it was noticed that the film appeared much brighter than that obtained with the nickel sulphate alone, and this characteristic was maintained until

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the solution acquired a deep blue colour. On examining the anode, after several plates had been coated in the solution, it was found to be covered with a dark brown and almost black layer on both surfaces, which firmly adhered to the plate. It was also observed that a flocculent precipitate formed in the solution, and deposited at the bottom of the vessel.

20. *Sulphocyanide of Nickel.*—A strong solution of sulphocyanide of potassium was first prepared, to which was added, a little at a time, moist carbonate of nickel, each portion being allowed to dissolve before the next was added. The solution, which was nearly colourless, was then filtered and electrolysed with the current from three cells, when, after a few seconds, a dark steel-grey film of nickel formed upon both sides of a clean brass plate, the character of which did not appear to alter during half an hour's immersion. Gas was given off at both electrodes.

21. *Carbonate of Nickel in Binoxalate of Potassa.*—A hot solution of binoxalate of potash was first made, to which was gradually added moist carbonate of nickel, the mixture being well stirred after each addition, and the resulting solution, which was of a pale green colour, after being filtered, was electrolysed with the current from three cells. There was a brisk evolution of hydrogen, and a rather dark-coloured deposit of nickel slowly formed upon the brass cathode, but, however, only upon the front of the plate facing the anode.

22. *Chloride of Nickel.*—To form a bath of this salt, ¼-ounce of the dried salt was dissolved in half-a-pint of water, and the solution then filtered for use. With the current from two cells, a fairly prompt deposit of nickel took place upon a clean brass plate, but the colour was not quite so white as that obtained from some other salts of nickel. There was a rather brisk evolution of hydrogen. A better result was obtained with the current from three cells and a diminished anode surface. The metal was not so fully adherent as deposits from the double sulphates of nickel and ammonia.

23. *Chlorides of Nickel and Sodium.*—To the above solution was added about 10 per cent. of chloride of sodium, but this did not appear to present any advantage; in fact, the colour of deposits obtained in the modified bath was rather darker than in the former case, while the film was still less adherent.

24. *Sulphates of Nickel and Potassa.*—A bath was prepared by mixing solutions of the respective salts, and the resulting liquid was then electrolysed with the current from three cells. The solution proved an indifferent conductor, and the metal deposited very slowly. After an hour's immersion the negative plate was found to be coated with a black, granular, non-adherent film on its lower surface, while a narrow band of white metal appeared on the upper surface. When the plate was gently heated over a spirit-lamp, the black deposit rapidly split up into minute particles, which jumped off the plate with great velocity—due, probably, to the sudden expansion of absorbed hydrogen. The black deposit, which appeared to be nickel in a semi-metallic state, readily dissolved in nitric acid, forming a green solution.

25. *Sulphates of Nickel and Magnesium.*—To form a bath, solutions of the respective salts were mixed, and the current from two cells used. Under these conditions a brass cathode soon became coated with metal; but this, however, had a very decided yellow tint, and was also very dull. The anode on both sides was of a dark brown colour. A third cell was then connected, and a newly-cleaned plate immersed, which quickly became coated with nickel, but, as before, of a yellowish colour. The anode, however, now became much cleaner, only exhibiting a few dark brown patches on parts of the plate. The brass plate was then well scrubbed with powdered bathbrick and water, when the yellow tint referred to disappeared, and a fairly white film presented itself. In this solution there was little or no evolution of hydrogen. The anode surface immersed was about equal to that of the negative plate.

26. *Citrate of Nickel by Electrolysis.*—A strong solution of citric acid was first made, in which was placed a clean plate of rolled nickel, connected to the positive wire of a 3-cell Daniell battery, and a clean brass plate, attached to the negative, was immersed in the liquid at a distance of about 1in. from the anode. The object of this experiment was to ascertain whether the vegetable acid, under electrolysis, would dissolve the nickel freely; and the trial was so far satisfactory, that in about fifteen minutes after immersion the brass plate became coated with a film of nickel, while the solution also acquired a slightly green tinge, showing that the metal was dissolving with tolerable activity. It was observed that the metal deposited from this solution was very bright, and of a good white colour. On applying a steel burnisher to the nickeled surface after the plate had been fairly coated in the above solution it was found to be much softer than is usual with nickel; indeed, the deposited metal received a high polish under the burnisher, which would not have been possible with nickel deposited from the ordinary nickel-plating solutions. It should be mentioned that one of the objects of these experiments was to obtain, if possible, a solution-bath which would yield coatings of nickel sufficiently soft to undergo the ordinary operation of burnishing, which, it was believed, would be an advantage to the nickel-plater for certain classes of metal work. It must be mentioned, however, that although some solutions of nickel appear to yield softer deposits of the metal than others, the strength of the current also appears to affect the hardness of the deposited metal to some extent—a fact which I have also frequently noticed in the electro-deposition of silver, copper, and other metals.

27. *Citrates of Nickel and Ammonia.*—To a solution of citrate of nickel, prepared as described in the last paper,* was added one of citrate of ammonia, a rather strong bath being employed. With the current from two cells, deposition took place somewhat slowly; therefore, a third cell was at once attached, when the brass cathode quickly became coated with a film of nickel, which, however, was somewhat dull, and not very white. An addition of water was now given, and a fresh plate immersed, when the subsequent deposit was much improved both in colour and brightness. The electrode surfaces immersed in the bath were about equal, under which conditions deposition took place very promptly. The nickeled surface was afterwards tried with the steel burnisher, which readily rendered the surface bright without severe pressure of the tool, indicating that the metal, as in the case referred to, was rather softer than ordinary nickel deposits. On examining the anode, it was found to be partially coated with green oxide, which, however, soon redissolved in the solution when it was at rest. To prevent the formation of this deposit on the anode a slight excess of citric acid was added, which had the desired effect of keeping the anode clean.

28. *Nickel Carbonate in Cyanide of Potassium.*—A solution was prepared by adding recently precipitated and moist carbonate of nickel to a strong solution of cyanide of potassium, the liquid being afterwards filtered and moderately diluted with water. With the current from two cells no deposit was obtained, and only a slight and patchy film was received upon a brass plate upon the addition of another cell. There was much hydrogen given off, and the solution failing to yield a good film was abandoned.

29. *Carbonate of Nickel in Bisulphate of Potassa.*—This bath was prepared by digesting moist carbonate of nickel in a hot solution of bisulphate of potassa, in which the nickel salt readily dissolved. The solution was electrolysed with the current from one, two, and three cells respectively, but only an indifferent film could be obtained with the latter current. A white flocculent precipitate formed after a while, rendering the liquid turbid; the solution was therefore cast aside as of no special interest.

30. *Ammonio-Chloride of Nickel.*—To a solution of chloride of nickel was added strong liquid ammonia until the solution acquired a deep blue colour. The solution was then electrolysed with the current from two small Daniells, and a clean brass plate immersed, which quickly received a white coating of nickel on both of the immersed surfaces. With the current named it was only found necessary to expose an anode surface equal to about one-third of that of the negative electrode. There was very little hydrogen evolved, but a rather more copious elimination of gas at the anode. It was noticed that the deposited metal was very bright, and of a good white colour.

* *Electrical Engineer*, May 24, 1889.

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31. *Ammonio-Nitrate of Nickel.*—To form a bath of this constitution, strong liquid ammonia was added to a solution of nitrate of nickel until the precipitate at first formed became redissolved. The current from two cells was used, and a brass plate received a film of nickel of a rather dark colour on both sides soon after immersion, the electrode surfaces being about equal. On examining the anode, after half an hour's immersion of the plates, it was found to be stained a deep brown, or almost a black colour.

32. *Ammonio-Acetate of Nickel.*—To a strong solution of acetate of nickel was added liquid ammonia until the solution acquired a deep blue colour. With the current from two cells a tolerably quick deposit of nickel was obtained upon both sides of a brass plate, which was of good colour, bright, and very adherent. To obtain the deposit at a fair rate of speed with the above current, a small surface of anode only was found necessary.

33. *Ammonoi-Citrate of Nickel.*—Strong liquid ammonia was added to a solution of citrate of nickel until a deep blue solution was obtained, which was afterwards electrolysed with the current from two cells. On immersing a clean brass plate it quickly became coated with a bright and white film of nickel, which adhered very firmly to the plate. As in the previous case, a very small anode surface was immersed—about one-third that of the negative electrode. The anode kept perfectly clean during the electroytic action.

34. *Ammonio-Carbonate of Nickel.*—The solution for this experiment was prepared by dissolving recently precipitated and moist carbonate of nickel in a strong solution of sesquicarbonate of ammonia, and the resulting liquid was electrolysed with the current from two cells. On immersing a clean brass plate it soon became coated with nickel, but as the colour of the film was rather dark, a third cell was connected, but not, however, with any apparent advantage, since the deposit still lacked whiteness. Moreover, the deposited metal from this solution was less bright than that obtained from the preceding bath.

35. *Carbonate of Nickel in Ammonia.*—A quantity of moist carbonate of nickel was next dissolved in strong liquid ammonia, and the resulting pale blue solution, after being moderately diluted, was tried with the current from two cells, but as deposition took place somewhat slowly, a third cell was connected. On immersing a freshly prepared plate in this bath, with small anode surface, a very bright film of a good white colour was speedily obtained, and even after an hour's immersion the deposited metal still retained its brightness.

(To be continued.)

ELECTRIC LIGHTING OF LONDON.

Prof. S. Thompson writes as follows to the *Times:*

"I have waited, expecting some expression from other pens of the feelings of astonishment and regret which the report to the Board of Trade on the subject of electric lighting has aroused in the breasts of some of those who have been, during the past ten years, most active in promoting this branch of scientific industry. That an enquiry, apparently so impartial and disinterested, should have resulted in conclusions so illogical, so obviously one-sided, and so inimical to the interests of a large section of the community, is, indeed, to be deplored. It is with the hope that some amendment or reconsideration may be effected before Parliamentary sanction is asked for the details of the scheme that I venture to address you. The report of Major Marindin, endorsed by the Board of Trade's adviser, Major Cardew, adopts the principle of the allocation of definite districts to definite companies, and sanctions the principle, doubtless in the interests of the public at large, of admitting more than one company into one district. The ostensible reason for this admission of the principle of competition is not, however, that of benefit to the public; the sole and only reason offered by the Board of Trade is much more specific. There are two general methods of electric supply—one known as the continuous current system, the other the alternating current system, the latter differing from the former in that the electric currents, instead of flowing steadily and continuously in one direction through the conducting wires, are incessantly oscillating in alternate directions. Each system has its advantages in particular cases, and certain companies have made themselves champions of the rival systems. The sole reason now alleged by the Board of Trade for admitting to one district two competing companies is that while the continuous current can be used not only for lighting lamps, but also for driving electric motors, so making the system of double use for the distribution of power as well as of light, hitherto it has been found impossible to use the alternate current to operate electric motors. Admitting that this important fact, though only one of a number of important facts, is entirely true, and that it affords a justification to the principle of competition between the two systems, what, I would ask, is the fair and natural inference to be drawn? What would, in face of this circumstance, be the procedure which should be fair to the companies who respectively apply for rights of supply in the districts and to the public who are the consumers? Because an alternating current company cannot supply the public with electric power as well as light, is that any reason for excluding from any district a company that can? Is it fair or right that in the only districts where absolute monopolies are granted, they should be granted to alternate-current systems? Is it fair or right that in districts which do not want an alternate current, but do want a continuous-current supply, that which they need and desire should be refused admission, and that which is incompetent to serve them should be allotted a monopoly? That is, however, exactly what the Board of Trade proposes; they propose to hand over nine-tenths of the allotted districts to the exclusive control of either the Metropolitan Electric Company or of the London Electric Supply Corporation, both these companies supplying only alternating currents in their respective districts.

"I pass to another point, which has been very conveniently slurred over in the Board of Trade report—namely, the uncertainty which attends alternate current supplies, arising from the impossibility of using accumulators with alternating currents. The alternating current system has no storage to draw upon; it lives from hand to mouth, as would a system of gas distribution in the absence of gasometers. A mere derangement of an engine or a boiler may, in the absence of storage, plunge a whole district into darkness. Is this, I would ask, any justification for the action of the Board of Trade in its determination to disallow over the greater part of the metropolis the entrance of any competition by companies that can use storage, and to hand over nine-tenths of the allotted areas to the monopoly of alternating current companies that do not and cannot use a storage system? Further, does it not seem monstrous that the whole of the proposals of the Electric Power Storage Company, one of the competing applicants, who asked not for a monopoly for themselves, but for fair field to compete with the alternating current companies, should by the Board of Trade's action be ruled out on a mere technicality, which could have been set right at Somerset House for a few half-crowns? This is not the kind of decision which the public expects from a semi-scientific tribunal, before which a system ought to be considered on its merits.

"The letter of Mr. Calcraft's which accompanies Major Marindin's report and promulgates the Board of Trade's decisions is curiously contradictory. He first announces that competing powers to two companies are given only in the following districts: St. George's, Hanover-square, a small portion of Lambeth, and a small portion of St. Martin-in-the-Fields. Further perusal of the letter shows, however, that this is not so, because by allotting powers in Chelsea and in St. James's, Westminster, to the London Electric Supply Corporation, this company, which is one of the two alternating companies, that proposed between them to cover nearly all London, is here admitted to districts where there already are other companies satisfactorily at work. In fact, Mr. Calcraft seems strictly to have adopted the notorious creed of the promoters of the London Electric Supply Corporation—namely, so long as they gain a footing in a parish, it matters not having a competitor; in so doing he not merely abandons, but deliberately inverts

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the sound principle laid down in his own report in 1883—that so long as a company in a district does its duty to the public, so long a competitor is not to be admitted. To the new principle of competition now announced he makes exceptions. Indeed, the cases of exception are more numerous than the cases in which the alleged principle is observed. For example, in Kensington parish, where a storage supply already exists, the district is to be divided between the existing and a rival alternating current system, but each is to be confined to a special sub-district, so that there is no competition; in the City, there are to be two companies, *both alternating*, and each is to have a definite sub-district Again, wherever the vestry in a district objects to competition, one company only will be admitted. The letter of Mr. Calcraft is effectual indeed in reducing the alleged principle of competition (in the interest of the public) between alternating and continuous supply to a mere farce. His principle of competition appears to be put in force only where it can serve the purpose of either of the two great alternating current companies—the London Electric Supply Corporation and the Metropolitan Electric Company; and it is dispensed with wherever it is convenient to give those companies a monopoly over their competitors. Even the meaning of the scientific evidence taken at the inquiry appears to have been misunderstood; for, from the body of the report, it is said: 'Of the scientific witnesses called as to the relative merits of the two systems of supply, the great majority were in favour of the alternating transformer system *for large areas*' (the italics are mine). This is a distinct misinterpretation of the evidence, which was throughout consistent in the expression of opinion that the alternating transformer was preferable not for large areas, but for what was called *scattered* areas—*i.e.*, districts in which there was a small number of consumers to be supplied in proportion to the area. It was not by any means the opinion expressed by the scientific witnesses that *dense* areas, whether large or small, were better supplied by transformers than by direct currents. The substitution of the word 'large' for the truer term 'sparsely populated,' entirely alters the drift of the evidence.

"As this letter has already extended to so great length, I forbear to add further criticisms. Doubtless such will be forthcoming from other quarters. I conclude for the present by repeating my protest against the illogical, lame, and unfair proposals which have been put forward in the name of the Board of Trade, and to express my hope that the London County Council will not sanction them until they have been so reconstructed as to remove their most objectionable features."

MESSRS. CROMPTON AND CO.

Last Friday—as a note in our issue of May 31 may have advised our readers—an exceedingly pleasant evening was spent at the Café Royal, in Regent-street, the entertainers being Messrs. Crompton and Co., and the *raison d'être* of the gathering to bring together the past and present pupils of the firm and some of the friends of the firm. Mr. Crompton, in the absence of the chairman of the company through illness, occupied the chair, and this was as it should be, for the visitors towards the end of the evening found that the day was the anniversary of the natal day of the chairman. It requires the lighter view of a society journal rather than the sober-sidedness of a technical paper to do justice to a gathering of this kind. The conception of such a meeting was a happy thought, as characteristic reminiscences hang around the works concerning those pupils who have long since left to occupy their energies in the wider sphere of industrial strife, and the present generation likes to be made acquainted with that that is gone. Many of Messrs. Crompton's old pupils are making a name for themselves in the world; many of the present pupils will be nerved to plod merrily along, having the success of their predecessors in view, and knowing that usually what man has done man can do again. We have long held the best way to win a place in the ranks of the electrical industry is to go through the works; and if to this is added theoretical training, the ideal state of apprenticeship is almost reached. Messrs. Crompton may claim to be one of the oldest, if not the oldest, of the firms who have attempted properly to train pupils for electrical engineering work. The firm has also from time to time inaugurated series of lectures on theory by such able exponents of the science as Prof. Fleming. But this is passing from the special to the general. Our immediate text is Friday's gathering, and if friendly faces and friendly expressions indicate the success of a firm, then Crompton and Co. must take a very high position indeed. The number of friends present was large, and from the Mayor of Chelmsford, who had just signed the contract for lighting Chelmsford, through the words of all other speakers, the gamut of praise was consistently sung. The evening's proceedings were enlivened with some excellent music, Mr. Gatehouse on the violin discoursing sweet sounds, while various songs contributed to the harmony. Genial Mr. Preece was in his happiest vein, and the scientific accuracy with which he proved the ancient invention of Daniell's cell, as well as of some other supposed modern inventions, will not soon be forgotten by those who listened, heard, and applauded Mr. Williams also let the cat out of the bag as to certain undetected ghosts which used to haunt Chelmsford, bringing the remark from the Mayor that he presided at the court and should certainly exert his authority if aught contrary to law was detected. We might, perhaps, say that the animal spirits of Chelmsford sometimes take another course than ghostly action, as some of our country contemporaries can testify.

The pleasantness of the evening was enhanced by a gentleman—not down in the regular programme to speak—asking permission to give his testimony of Messrs. Crompton and Co. from a purely business point of view. The testimony was exceedingly good, the gentleman having obtained from the firm something out of the common way with great dispatch, and having been greatly pleased with the obliging manner in which his enquiries were met.

We cannot conclude this brief reference to a delightful evening without mention of a question which affects the well-being of the technical press. The unanimity of the speakers on this point was conspicuous—that Messrs. Crompton and Co. were always more than ready to give all possible information upon their work and manufactures, making it a pleasanter task to meet than it was to obtain similar information from firms whose efforts were seemingly directed to keep secret what really was no secret, and what really could not be kept secret.

The proceedings ended by a hearty vote of thanks to the chairman, who cannot but feel gratified at the great success of these annual meetings.

ELECTRIC MINERS' SAFETY LAMPS.

To the Editor of the Electrical Engineer.

Sir,—Mr. Niblett has asked me a question which I fear is not easy to answer. The position of the incandescent lamp itself, in the miners' portable electric lamp, is a matter that will really only be decided after extended practical use. At present, all that we can do is to indicate the position which, so far as one can see, offers fewest disadvantages. This, I think, is the position which Mr. Pitkin and Mr. Swan have chosen for their lamp.

On the top, the light is in one's eyes, you do not get the same amount of light in any given direction as when the rays are concentrated, and you have no light on the ground immediately at your feet, underneath the bottom of the case. You have no light upwards, and the arrangement presents certain mechanical and electrical difficulties. On the side, you have the advantage of being able to concentrate the rays from your lamp, so as to obtain a higher degree of illumination in any given direction, while, provided the apparatus be properly constructed, you can turn the rays of the lamp upon any object in any position.

The connections to the lamp are more easily arranged when it is placed on the top, but there are no serious difficulties involved in placing it on the side.

One requirement that Mr. Niblett has named is, I think, hardly necessary. It will, perhaps, be better for the lamp to be strong; but no collier makes a seat of the existing Davy lamp.—Yours, etc., Sydney F. Walker.

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IMPORTANT NOTICE.

Although the Paris Exhibition is open, the major portion of the exhibits are in so backward a state that any systematic description is almost impossible at present, so we shall wait a short time till the chaos of packing cases becomes a neat arrangement of exhibits. It is needless to tell our readers that—so far as our description of the electrical exhibits is concerned—our attention will, in the first place, be directed to the interests of English and American exhibitors. A special edition of this paper, with the report of the exhibition in two languages—English and French—will be obtainable in the Exhibition.

THE ELECTRIC CONSTRUCTION CORPORATION.

The prospectus of this company has been issued, and although it does not completely follow the lines indicated by us last week our forecast was, broadly speaking, correct. The interests amalgamated by this combination are connected more directly with accumulators and traction. Two good businesses are absorbed, and will form the nucleus of what should be a good manufacturing concern. The Electrical Power and Storage Company had a unique position. Through evil report and through good report it pursued the even tenour of its way, and to that company, in conjunction with Elwell-Parker, the accumulator business owes its position to-day. The Electrical Power and Storage Company and Elwell-Parker combined form a substantial source of action, but besides these the promoters have brought into the net the Julien and the Sprague interests, the latter of which has been particularly successful in the States. The position of a technical paper in the criticism of this new company is rendered exceedingly difficult, because, as a combination, the company is sound, and under the proposed management it should be a great success. Had this combination been brought about without any company-mongering proclivities, it would have been impossible to do aught but praise the action. As it is, we must utter our emphatic protest against the method and results of promotion. Unless we are greatly mistaken, the workers—that is, those who have to get the trade and earn the dividends—do not care to be handicapped with huge sums gone as promotion-money. A millstone of at least a hundred thousand pounds has in this case been hanged around their necks. While, then, we are in thorough accord with the combination in its working capacity, we are wholly antagonistic to the finance of its promoters. Let us assume that the promoter is worthy of his hire, and that his business is to get all he can ; our business is to spoil his little game if we believe the public are being fleeced unnecessarily. In these cases the public have to pay the piper, but it is seldom that they can call the tune.

The prospectus, p. 10, refers to a number of contracts made between various firms and gentlemen on the one part and Mr. Herbert Edward Tarver on the other part, *which can be inspected* ; and on p. 11 refers to numerous contracts made between the said Mr. H. E. Tarver and others, which *cannot be seen.* In other words, a Tarver or any other name would act just as well. He is not the real negotiator, he does not take the plunder, though he is put forward and much made of his "arduous" labours. Well, over a hundred thousand pounds will console most men for some pretty difficult work, far more difficult, we should imagine, than anything done in connection with this scheme. We speak of a

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hundred thousand pounds advisedly, because, according to the "to be seen" contracts, Mr. Tarver pays in cash and shares £288,000 for something for which he gets £397,300 and certain interest. Now the difference between these two amounts is £109,300, which is paid by the company to somebody for something. We can find the ostensible somebody, but is the work done by the somebody worth £109,300. Who is Mr. Tarver? Singular to say, his name does not figure among the list of founders, so that if there be any reality in Mr. Tarver he has no great affection for the child he has created. Dean Swift may have had a figure-head company-monger in mind when he wrote: "How fading and insipid do all objects accost us that are not conveyed in the vehicle of delusion! How shrunk is everything as it appears in the glass of Nature, so that if it were not for the assistance of artificial mediums, false lights, refracted angles, varnish and tinsel, there would be a mighty level in. . ." Is Mr. Tarver an artificial medium or a vehicle of delusion. If so, where and who is the real Simon Pure? We can make a very shrewd guess, and if there were any righteous laws in company promotion we could soon get at the truth by inspecting the now "not to be seen" contracts.

It has been suggested to us that the working capital remaining after the payment of the £397,300, will be insufficient for the requirements of the company. Those who hold this opinion can hardly have considered the matter fully, and saying this, it is hardly necessary to give our opinion that the working capital will, for a long time to come, perhaps always, be amply sufficient. If only half of what is going to Mr. Tarver and Co. had gone to increase working balance, no doubt as to its sufficiency would have arisen.

After writing thus far we followed the Addisonian practice and dreamed a dream. In that dream we seemed acting with company promoters, whose *modus operandi* was to lay hold of something good, to manipulate matters among a clique so as to get a good big sum, promotion money, underwrite half the share capital, divide the founders' shares and promotion money *pro rata*, deduct a certain part of the promotion money to rig the Stock Exchange and nobble the press. In a particular concern one masterful man would have 2,000 ordinary shares of £5 each. From the promotion money he got £8,000. By manipulating the market the shares were rushed to £2 premium. He sold out 1,500 shares, making a profit of £3,000, or getting a total of £11,000, out of which he paid for 500 shares £2,500, making a clear gain of £8,500, or rather of £7,700, for he had to contribute £800 towards preliminary and other expenses.

Then came the awaking, and behold we applied the dream figures to the actual case before us. We assume that £75,000 is all that Tarver and Co. realise nett profit. Each founder's share then gets £750 of this, so that if the shares reach a premium of £1, and 200 out of the 250 ordinary shares which carry one founder's share are sold, the money received will be 750 + 200, or £950, while the cost of the remaining 50 shares will be £250, leaving a nett gain of £700. If he unloads only 100 shares, he will get his 150 remaining shares for nothing, and be £100 in pocket. Take as a specific example the largest amount underwritten—viz., 1,500 shares. According to our assumption, this carries £4,500 of the promotion money. If the shares go to a premium of £1, and 1,000 are sold, the total gain is £5,500, out of which £2,500 is paid for the remaining 500 shares, the underwriter getting £3,000 nett, or, in other words, has 500 shares for nothing and pockets £3,000 because he was one of the promoters.

No doubt the financial promoters will give us their approbation for our humble efforts to unravel this riddle of how it is done. We shall receive their good opinion with gratitude, and to the utmost of our poor capacity shall take hold of all opportunities to return the obligation.

THE TELEPHONE COMPANIES.

In our issue of April 12th we discussed the proposed amalgamation of the telephone companies. Since then other incidents have arisen which have somewhat altered the position of affairs. The Government practically vetoed the original scheme, and another has been proposed in its place. The telephone companies seem determined to force the hands of the Government, though we suspect the final result will be that the shareholders would have preferred to see their directors banished to Siberia rather than placed in the position they will be.

Firstly, let it be clearly understood that the telephonic wire-pullers are looking after number one. They will make money whatever happens to the shareholders. They are behind the scenes, can sell or buy with perfect safety, and most certainly they will be found unloaded when the crash comes. There are ominous signs that the Government will not long delay action. The reply of Mr. Raikes to Mr. Chamberlain and his letter to the telephone companies are proofs of this. The telephone companies, too, recognise the fact, and admit the present position to be a fair stand-up fight. At least we can find no other interpretation to Mr. Brand's views, given at the meeting on Tuesday, expressed as follows: "The Postmaster-General, who, in the pursuit of the duties of his office, was a very keen trader, would certainly be more able to bring his devices to pass if he had to deal with

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the various companies singly, than if he had to deal with one great company, strong in unity, in financial position, and with one strong executive body." An attempt was made to qualify these views in the succeeding part of the speech, but they cannot be qualified. Put into plain English, the words mean "We amalgamate the better to fight." Now, whatever happens, the shareholders will have justice, but if Messrs. Brand and Co. imagine for a moment they are going to force one stiver more from the public purse than they are justly entitled to, they are greatly mistaken. Their management of the telephone ring has been patent for years. The subscribers have not been thought of. The management cannot justify any claim to vested interests; they have none. The lines would be a disgrace to a country blacksmith, in that it is only by chance you can get clear intonation in speaking. More often you have to guess half what your correspondent is saying than to be certain on the subject. That the difficulties can be met and overcome is an undeniable fact, for they are avoided in towns other than London. The major portion of the subscribers would welcome any change that would bring about improvement, and as the Government officials and other companies have shown what really can be done in the North and in the West, the sooner the present incompetent London management becomes a thing of the past the better. Unfortunately, the United Company dominates, more or less, all the other companies by its holding of shares, and we contend it has all along been a drag upon the true development of the telephonic industry. More than once we have stated the true policy for its shareholders. The work should have been done in the best possible manner, the interests of subscribers consulted, the price diminished and the number of subscribers increased to the utmost extent. As it is, the work will mostly have to be pulled down and replaced, the cross talking stopped, clearness of intonation obtained, and the cost lowered till a reasonable amount is charged. We are not the exponents of the Government policy, yet we give an emphatic denial to Mr. Brand's statement that every obstacle had been put in the way of the company. He is absolutely wrong. Telephony is a branch of telegraphy, and why the Government is to forego its claims in order to benefit a set of private individuals, why the public is to lose its just reward to benefit them, is beyond comprehension. Government officials are kicked much more often than praised, and it will be well occasionally to admit that their efforts are calculated to benefit the general public, and not to gain a fleeting popularity by pandering to company-mongers.

Biographical.—An interesting life, with portrait, of the Secretary of the Society of Arts, Mr. H. Trueman Woods, appears in the *Mining Journal* for June 1, 1889.

POCKET AMMETERS AND VOLTMETERS.

The pocket-measuring instruments illustrated herewith are made as ammeters or as voltmeters, and are likely to prove exceedingly useful to electrical engineers who require a thoroughly portable and neat little pocket instrument. The illustrations show the instrument in full size. They are made in the form of a watch, nickel-plated outside

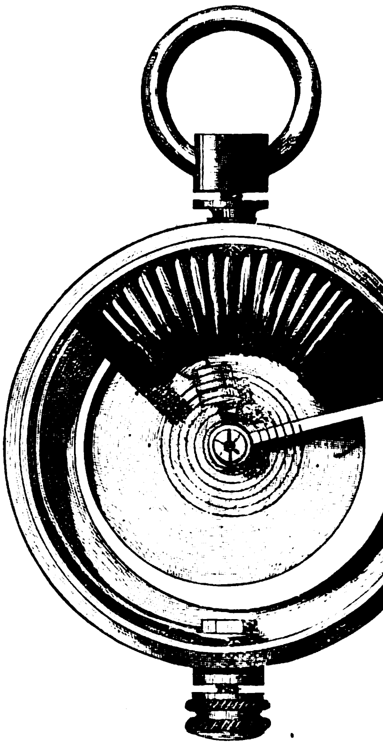

Fig. 1.

Fig. 1 shows the works. A solenoid is arranged with a tapered curved core, which is sucked therein under the action of the current. The core is controlled by a long spiral watch spring, made of a special material, which is selected to withstand changes of temperature. Fig. 2

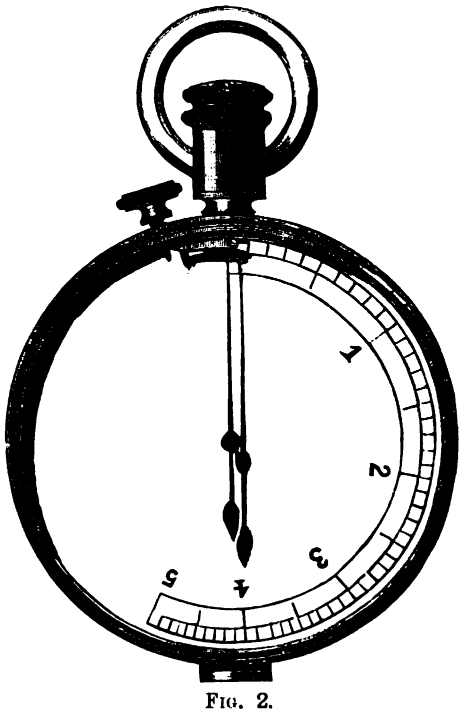

Fig. 2.

shows the instrument in front view, in this case reading from one to five amperes. They are also made to read from 10 to 50 amperes. The voltmeters are made to read from one to five volts, 10 to 50 volts, and 20 to 100 volts. The deflection for one volt or one ampere is 20deg., so that great accuracy can be obtained in the measurement of small currents. The connections are made at the top

and bottom of the instrument; the screw shown within the ring in Fig. 2 unscrews and fits into the threaded hole at the bottom. A little screw, to which a small finger is attached, clips the needle and keeps it from swinging loose when not in use. The pivots supporting the hands work in jewelled holes. We have inspected these instruments, which are made by Messrs. Mayfield and Co., Limited, and they seem to be very neat and thoroughly serviceable for the purpose intended.

JAPAN AND CHINA.

The extremely hazy ideas which possessed the minds of our people with respect to these two countries up to a comparatively recent period have not been entirely eradicated, for we meet with persons of average intelligence who still regard their peoples as bearing, in some undefined way, close relationship, whereas no comparison can really be instituted. This is especially evident when we take into consideration the progress made by Japan in public works in the past twenty years, while China has practically been inactive. All that Japan possesses in common with China now are those square hieroglyphics which do duty as letters in books and manuscripts, and even here Japan has left her unwieldy neighbour far behind in the race, for she has an abbreviated character of her own, forming a syllabary capable of expressing every sound of the language in 45 signs, in lieu of the enormous total of fifty thousand or more (some seven thousand of which are in regular the daily use), comprised in Chinese dictionaries. In fact, the Japanese tongue has an alphabet, but the Chinese has none, and the Japanese could do without the square hieroglyphic entirely were it not for their ancient literature, which has been derived principally from Chinese sources any time within the last fifteen centuries. In their manners and customs, modes of thought, enterprise and pluck, their marvellous adaptability to new surroundings, and, not least, their thoroughly martial spirit, the people ruled by the Mikado differ from the tortoise-like subjects of the Court of Pekin, as light from darkness.

Japan is building her own railways and telegraphs, and undertaking nearly all her public works by native engineers and workmen. Already the telegraph mileage measures well into five figures, and the railways in operation or in course of construction extend over 2,000 miles.

The Chinese are at last moving, and if no misfortune attends the railway now being laid, they may in reality carry the line up to the gates of Pekin, from its ports of Taku and Tientsin, and the mines of Kai-ping. But a collision or other accident, with the slaughter of a mandarin or two, would inevitably check farther progress.

Electric lighting, after being a failure for a time, is gaining ground in both China and Japan, but the field is a wide one, and there is room for much more enterprise on the part of our manufacturers than they have hitherto shown. Continental firms have had orders placed with them which ought to have come to us had our people been sufficiently wideawake.

It is not too late to remedy this if what we hear be true, that a great impetus is to be given to electric work of all kinds in both countries by native guilds. Electric lighting, telephones, telpherage, all will have their share, and, admitting that the clever Japanese turn out splendid instruments and fittings of all kinds, they are still indebted to Europe for wire for both open and covered work. They cannot draw iron wire properly yet, or make good cables, though they do nearly everything else. One or two of our firms have travelling representatives out in the Far East, but there is a vast amount of work in contemplation, and a grand opening for capital and energy. The tendency out there now is to raise the requisite funds and undertake this class of work by local companies, all of which ought thus to be good customers if well looked after. The Government is gradually retiring from what may be termed commercial undertakings, content to merely maintain a watchful eye over them, whilst enriching its exchequer with the fees on licenses.

It well known that our traders in the Far East are somewhat severely handicapped in the struggle for business in competition with those of Continental nations. Our consuls and other officials are prohibited—and rightly so from our point of view—from engaging in any trade or occupation other than that which strictly appertains to the discharge of the consular function. But with most other European nations this is not the rule, and the consul is usually himself a trader, and may reasonably be held to derive some advantage from his official rank in dealing with the native merchants. For a proof of this one has only to observe the eagerness with which the office is undertaken when a vacancy occurs. There is no way of fairly balancing this unequal competition; but something may be done by the establishment of agents possessing local knowledge and speaking the language.

To sum up, there is an excellent opportunity now for extending our business relations with both Japan and China, but we seem to need something more than the mere despatch of trade reports and circulars to secure the business. It requires pushing on the spot. Yokohama was, some time since, partially lighted electrically by an English merchant who we believe is a chemist, and who, we may suppose, brought no special skill to bear upon the work. He possessed, however, the very serviceable qualifications of energy and capital.

It is very evident to anyone who has been out there that a large amount of business could be at once procured if British merchants would properly bestir themselves.

THE EFFICIENCY OF METHODS OF ARTIFICIAL ILLUMINATION.*

BY EDWARD L. NICHOLS, PROF. OF PHYSICS IN CORNELL UNIVERSITY.

(*Concluded from page 433.*)

An Edison lamp, similar to that which had been used as a standard in our previous measurements, was subjected to spectro-photometric analysis by Mr. Franklin and myself at four candles, 10 candles, 16 candles, 22 candles, and 28 candles successively. The results obtained are shown in Fig. 9.

The spectrum of the lamp at 16 candles is taken as of unit brightness throughout, and the other curves show the amount of light of each wave-length emitted by the lamp in the above-mentioned states of incandescence. Intensities, in every case, are referred to the light of corresponding wave-length, given by the same lamp at 16 candles, as unity.

At the red end of the spectrum the intensity increases more slowly than candle-power, at the violet end more rapidly. There exists an intermediate wave-length, for which the brightness is proportional to the candle-power. The vertical line in the diagram shows the portion of the spectrum for which this holds true, a point in the yellow at wave-length 6,000.

If we suppose the same measurements executed upon a set of lamps in every respect similar to the one in question, excepting that their radiating surfaces are of such size that they give 16 candles, as indicated by the Bunsen photometer when the degree of incandescence corresponds respectively to that at which the lamp actually measured emitted at 4, 10, 16, 22, and 28 candles, there would result a set of curves of the same general character as those in Fig. 12. At wave-length 6,000, these curves would have a common value, and they would serve to indicate both the quantity and quality of the variation of the carbon filament as a function of the incandescence, candle-power remaining constant. The form of these curves is shown in Fig. 10. They afford us data for discussion of the candle as a standard of illumination which could not be obtained in any other way. They show the relative distribution of energy in the spectrum of five lamps, which, according to the indications of the Bunsen photometer, are of equal brightness, but which differ both in the quality and in the total energy of their luminous radiation. Their efficiency expressed in terms of the candle-power produced per watt expressed

* Paper read before the American Institute of Electrical Engineers, March 12, 1889.

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in the lamp, rises rapidly as the incandescence increases. For lamps of the type upon which these measurements were made, for instance, the relative efficiency referred in each case to that of the lamp, the incandescence of which corresponds to that of an Edison lamp at 16 candles, is given in the column headed $\frac{\text{Candle-power}}{\text{Watts.}}$ in table VII.

TABLE VII.

State of incandescence equivalent to that of an Edison 16 c.p. lamp giving—	Relative efficiency referred to that of a 16 candle lamp as unity.	
	Candle-power / Watts.	Luminous radiation / Total radiation.
(1) 4 candles	·394	·211
(2) 10 candles	·729	·632
(3) 16 candles	1·000	1·000
(4) 22 candles	1·218	1·368
(5) 28 candles	1·391	1·589

If, however, we retain as the measure of efficiency the ratio, $\frac{\text{luminous radiation}}{\text{total radiation}}$, we can deduce from these curves values coinciding with those reached by the method of the thermopile and alum cell. To this end we must know the above-mentioned ratio for some one candle-power and the number of watts necessary to the production of each state of incandescence for which the computation is to be made.

The relative efficiency can then be calculated from the areas enclosed by the respective curves. Were the candle-power proportional to the energy of luminous radiation, the values thus obtained would be identical with relative efficiency determined from the relation of candle-power to watts. The relative efficiency thus computed (see table VII.) does not coincide with that obtained from the ratio of watts to candle-power, however, for the reason that the various rays which make up the visible spectrum do not enter into the production of candle-power in proportion to their energy. The most important wave-lengths, so far as light-giving power is concerned, are those which form the yellow of the spectrum, and the relative luminosity falls off rapidly both toward the red and the violet. The longer wave-lengths have, however, much more influence upon candle-power than the more refrangible rays, as will be seen by an inspection of the curves, the relative falling off of the red end of the spectrum being compensated by larger and larger accessions in the blue and violet as the state of incandescence increases.

Luminosity is the factor which we must take into account in seeking a complete expression for the efficiency of any source of illumination, and the method to be pursued in the determination of the luminosity must depend upon the use to which the light is to be applied. If we estimate light by its power of bringing out the colours of natural objects, the value which we place upon the blue and violet rays must be very different from that which would be ascribed to them if we consider merely its power of illumination as applied to black and white. In a picture gallery, for instance, or upon the stage, the value of an illuminant increases with the temperature of the incandescent material out of all proportion to the candle-power, whereas candle-power affords an excellent measure of the light to be used in a reading-room.

A number of determinations of the luminosity of artificial light have been made. In the earliest of these by Vierordt* the amount of white light which may be mixed with each colour of the spectrum, without producing an appreciable change of tint, was taken as the measure of the luminosity of that colour. The result is shown graphically in Fig. 11. The curve indicates the light-giving power of each wave-length, estimated in the above manner. The source of light experimented upon was a petroleum flame. The vertical line indicates the region of the spectrum within which — according to the measurements of the quality of light of the incandescent lamp already described —the increase in the brightness of the spectrum is proportional to the candle power. This region corresponds very nearly with that of maximum luminosity of the spectrum.

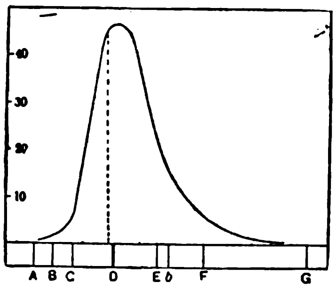

FIG. 11.

The luminosity of the blue and violet rays is so very small that in the production of candle-power the influence of the very rapid growth of this end of the spectrum with increasing temperature of the lamp is scarcely appreciable. If we estimate the light-giving value of the different portions of the spectrum by means of the facility with which we can distinguish black characters upon a white ground, the importance of the more refrangible rays is still farther diminished. Thus Mace de Lepinary and Nicati* have shown that if yellow and blue light, estimated to be of equal brightness by photometric means, are of such intensity that one can clearly distinguish a printed page when illuminated by the yellow, the same page will be entirely illegible when the blue light alone falls upon it. These observers conclude, indeed, "That mere distinguishing of objects is due almost exclusively to the illumination produced by the less refrangible half of the normal spectrum," so that at equal brilliancy "the superiority of yellow sources of light (luminous gas flames, incandescent lamps) over sources richer in blue rays (light of the electric arc) is incontestable." "The only real advantage," they add, "upon the side of the light from the electric arc is when one desires to rehabilitate objects more nearly in the hues which they present in the light of day." This single advantage is one which it is impossible to take due account of, numerically, in an estimate of the efficiency of artificial illumination. It is nevertheless a most important factor in determining the adaptability of a light to nearly all the purposes of everyday life.

Otto Schumann,† to whom we owe a most exhaustive study of the light of the incandescent lamp, has determined the luminosity of several types of such lamps at various stages of incandescence. His results, in so far as they apply to a 16-c.p. Edison lamp, are given in table VIII.

TABLE VIII.

Luminosity of an Edison lamp at various stages of incandescence, according to Otto Schumann.

Amperes.	Volts.	Watts.	Luminosity of various regions of the spectrum.						
			Red λ= 676	Or'nge λ 656	Yellow λ 615	Green λ 557	Blue λ 487	Indig λ 464	Violet λ 439
0·625	87·3	54·6	1·18	4·64	—	20·14	0·64	0·11	—
·678	90·4	61·3	1·68	6·66	—	30·35	1·05	0·20	—
·727	94·7	68·8	2·24	9·34	53·11	50·05	1·71	0·34	—
·748	97·4	72·9	2·59	10·92	63·28	62·23	2·28	0·47	—
·823	105·0	86·4	4·06	17·14	99·22	104·3	4·09	0·88	—
·944	112·9	106·7	6·97	28·85	163·0	189·1	7·88	1·75	—
1·009	117·6	118·6	8·74	37·14	222·6	255·7	11·62	2·71	0·42
1·035	120·4	124·7	9·36	41·67	263·3	317·7	16·04	3·79	0·60
1·099	124·5	136·4	11·43	52·36	345·2	472·2	26·24	6·53	1·04

I have made these values of Schumann's the basis of a set of curves, by means of which the variation in luminosity, with total energy in watts, is exhibited (see Fig. 12). It will be seen that the position of the maximum moves slightly toward the violet as the brightness of the lamp increases. This tendency is very slight within the range

* C. Vierordt, *Annalen der Physik und Chemie*, Bd. 137, p. 200.

* Mace de Lepinay and W. Nicati, *Journal de Physique*, second line, T. 2, p. 75, 1883.

† Otto Schumann, *Elektrotechnische Zeitschrift*, Bd. 5, p. 224, 1884.

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of temperatures reached by the incandescent lamp. In the arc light we should find the displacement more marked, but in the case of sunlight, in which, as we have seen, the shorter wave-lengths are in such preponderance, the movement of the maximum is inconsiderable. The curves shown in Fig. 13 are taken from the investigation by Crova, who has determined the distribution of luminosities in the spectrum of sunlight, and of the flame of a petroleum lamp. The maximum in sunlight is at $\lambda = 582$, that of the petroleum $\lambda = 592$. Nearly all sources of illumination will be found to have a maximum lying between these two wave-lengths.

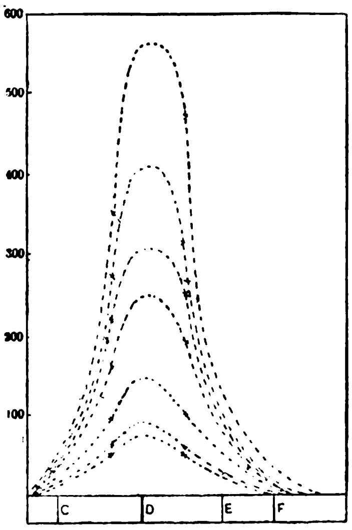

Fig. 12.

A comparison of the total luminosity of the incandescent lamp with its candle-power shows that the former increases with the energy of the lamp more rapidly than the latter, although the discrepancy is not so marked as in the comparison of efficiency of candle-power with that of luminous radiation.

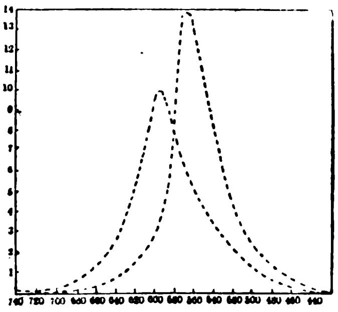

Fig. 13.

The following table, obtained by the summation of the luminosity curves, shows the relation between candle-power and total luminosity, in the case of the lamp studied by Schumann.

Table IX.

Candle-power and total luminosity of the incandescent lamp.

Watts.	Candle-power.	Total luminosity.
54·6	—	4·11
61·3	—	6·31
68·8	10·12	10·20
72·9	12·05	12·58
86·4	18·80	20·64
106·7	31·60	36·80
118·6	41·44	49·77
124·7	50·16	60·85
136·4	64·15	—

Plainly, then, candle-power does not afford a measure either of the light-giving energy or of the luminosity of a source of illumination. When used in the comparison of sources which differ in temperature, the indications of the photometer always yields us relatively too low a value for the intensity of the lamp of higher incandescence. In the case of candles *v.* gas, or either of these in comparison with the incandescent lamp at normal temperature, the error is not important, but between the candle and the "16-candle" lamp maintained at 50 candle-power, the discrepancy amounts to 10 per cent. For the electric arc the ratio of candle-power to total luminosity is very nearly 4 : 5, and in the case of daylight is about 4 : 6.

In arc light photometry candle-power is already a well-nigh meaningless term. Would it not be well to abandon it altogether in favour of some standard affording us an expression for the luminosity of radiation? So far as the incandescent lamp is concerned, light-giving power is a perfectly definite function of the temperature, and of the area of the radiating surface. We are, unfortunately, not in a position at the present day to measure the temperature of an incandescent filament, but the time will undoubtedly come when the relation between the temperature and the quality of the light emitted by glowing carbon will be definitely known. We may, indeed, look forward to the development of some optical method for the measurement of the temperature of incandescence which shall be as easily performed as our present method of determining candle-power, and which shall admit of a much higher degree of precision. The comparison of lamps, the temperatures of which are the same, will then reduce itself to a question of radiating surface. Total luminosity and total energy of luminous radiation, per unit of surface, together with net and gross efficiency, may then be expressed, in so far as incandescent carbon is our source of illumination, as functions of the temperature alone, and the performance of any lamp may be defined in terms which admit of no uncertainty.

ALTERNATE CURRENT WORKING.*

BY W. M. MORDEY.

(*Continued from page 439.*)

From Sir William Thomson's address, and from some further information he has kindly sent me, I have worked out and tabulated some figures, showing what restrictions are imposed by the virtual increase of resistance of solid conductors with alternating currents, as bearing on the question of periodicity.

Sir William Thomson gives some figures for a periodicity of 80, to which I have added some columns giving diameter in inches, sectional area, and the current which the practicable sizes will carry, taken on the basis of 450 amperes per square inch, because that density gives 1 per cent. loss per mile with 2,000 volts. It also gives about 1 per cent. loss per 100 yards with 100 volts, or, more exactly, 1·15 per cent. I have also given the number of watts at 2,000 volts, and at 100 volts, for each size, to show the limits for ordinary primary and secondary working with this density. These figures are given for 80, for 100, and for 133 periods, the diameters of conductors for the same percentage increase of virtual resistance over ohmic resistance being in the inverse ratio of the square roots of the periodicities.

Table I.—*Virtual Resistance, etc., of Conductors with Alternate Currents.*

Diameter		Area.		Increase over ordinary resistance.	Current at 450 amperes per sq. in.	Watts at 2,000 volts.	Watts at 100 volts.	Periods per second.
MM.	Inch.	Sq. mm.	Sq. in.					
10	·3937	78·54	·122	Less than $\frac{1}{100}$ %	55	110,000	5,500	80
15	·5905	176·7	·274	$2\frac{1}{2}$ %	133	266,000	13,300	
20	·7874	314·16	·487	8 %	220	440,000	22,000	
25	·9842	490·8	·760	$17\frac{1}{2}$ %	—	—	—	
40	1·575	1,256	1·95	68 %	—	—	—	
100	3·937	7,854	12·17	3·8 times	—	—	—	
1,000	39·37	785,400	1,217	35 times	—	—	—	
9	·3543	63·62	·098	Less than $\frac{1}{100}$ %	45	90,000	4,500	100
13·4	·5280	141·3	·218	$2\frac{1}{2}$ %	98·5	197,000	9,850	
18	·7086	254·4	·394	8 %	178	356,000	17,800	
22·4	·8826	394	·611	$17\frac{1}{2}$ %	—	—	—	
7·75	·3013	47·2	·071	Less than $\frac{1}{100}$ %	32	64,000	3,200	133
11·61	·4570	106	·164	$2\frac{1}{2}$ %	74	148,000	7,400	
15·5	·6102	189	·292	8 %	131·4	263,000	13,140	
19·36	·7622	294	·456	$17\frac{1}{2}$ %	—	—	—	

It will be seen that for 100 periods, with wires of 9 millimetres, or ·35in. diameter, the increase over the ordinary resistance is almost imperceptible; for a diameter of 13·4 millimetres, or ·53in., it is only $2\frac{1}{2}$ per cent.; while what may be considered a practical limit is

* Paper read before the Institution of Electrical Engineers.

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reached at 18 millimetres, or nearly ¾in. At greater diameters the increase is prohibitive, and multiple conductors, tubes, or strips must be used. Probably an increase of 8 or 10 per cent. will be considered quite permissible. It sounds a good deal; but it must be remembered that it is only 8 or 10 per cent. of the 1 or 2 per cent. loss for which primary conductors are usually calculated.

Looking at the limitations as regards output, it may be said that for primary distribution, even at no higher tension than 2,000 volts, the virtual resistance effect is, if not quite unimportant, at any rate not very serious. A current of about 200 amperes may be conveyed without the effect showing itself to any very objectionable extent. There may be differences of opinion on the subject, but most people will agree that 300,000 or 400,000 watts is quite as much as should be supplied through any single conductor. In most cases, even at ordinary tensions, subdivision of the primary will be necessary or advisable before such a power is reached. With still higher pressure, of course, enormous powers can be dealt with without exceeding the permissible size of solid conductors. It is to be observed that there is nothing in this virtual resistance effect to necessitate the reduction of current by the employment of very high pressures.

It is only with the low-tension secondary conductors that this effect becomes in any way serious. With 100 volts the maximum load at this density that can be put on a single solid or stranded conductor is about 13,000 watts for 133 periods, 18,000 for 100 periods, and 22,000 watts for 80 periods, unless much more than the 8 to 10 per cent. increase can be endured. This only means in large distribution work a subdivision of the primary and secondary feeding points in accordance with this limitation. The inconvenience has only to be recognised to be avoided. Fortunately it is not one that with ordinary care is likely to lead to any practical inconvenience. It exists with alternate currents, but it is a matter that the transformer system renders it very easy to avoid. Transformers lend themselves to subdivision of work, and with subdivision this difficulty does not exist.

It may be worth noting, in connection with this part of the subject, that the improvement in alternators, and the great ease with which they and their circuits can be worked and controlled, may lead to some revival of the practice of supplying direct from low-tension alternators. If this is done for any but very small installations, it is evident that special precautions must be observed to avoid the difficulties which have been referred to.

One other remark on this subject. Very large conductors are to be avoided in the transformers as well as outside of them. This is only mentioned on account of its bearing on transformers for any very low-tension work, such as electric jointing or welding, where one or two turns of secondary conductors is often sufficient.*

4. *Transformers.*—There appears to be a general belief that a high periodicity is best for transformers, and that this gives the greatest output, or—what amounts to the same thing—that with the same output in the two cases a higher efficiency is obtained when the periodicity is high than when it is low. This supposed fact has often been stated.

Prof. Forbes—who has, I believe, given much attention to the theory of this very difficult subject—contributed a paper last year,† consisting of a mathematical examination, which is summarised and concluded by a statement that the periodicity may be diminished without loss of efficiency if the iron be increased; the corollaries being, of course, that the periodicity may be increased without loss of efficiency if the iron be reduced, and that with any given transformer an increased periodicity results in increased efficiency for the same output, or in greater output with the same efficiency.

Prof. Forbes confirmed this view recently, in the discussion on a paper by Mr. Kapp before the Institution of Civil Engineers, by pointing out that one of the reasons why in America they used a high periodicity was that "they wanted to get the greatest output from their plant, and transformers had to be increased in size in order to give the same output if they lowered the number of alternations."* And in his recent paper on "Central Stations" before this institution,† Prof. Forbes reiterated this. He states that the contrary is "opposed alike to experience and theory. Westinghouse knows this. I am informed Mr. Ferranti knows it, and Mr. Zipernowski has told me that he finds it so."

Mr. Kapp, who works at 80 periods, does not go so far as Prof. Forbes, for he thinks that on account of viscous hysterisis there must be a limit beyond which an increase becomes disadvantageous. He wisely adds that it is not possible to determine this limit on theoretical grounds.

On the other hand, it has been said that it is not necessary to increase the size of transformers even for very low periodicities, because, when the number of cycles is small, it is possible to work at a higher magnetic density.

I venture to question the accuracy of both these extreme views.

So far as transformers are concerned, and speaking only from experience, I think that high and low periodicities are both wrong, and that a medium rate is right. For a given output and efficiency, not only must transformers be made large for low rates—they must also be made large for high rates; but between the two there will be found a periodicity giving the smallest size of transformer, or the greatest output, or the highest efficiency.

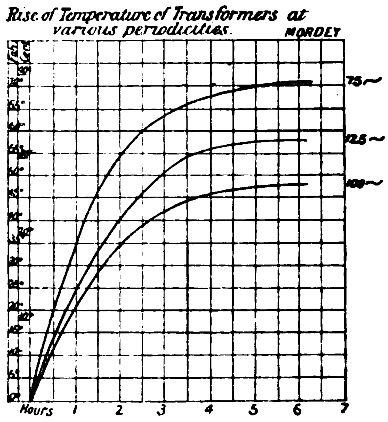

Fig. 2.

Fig. 2 illustrates this. It shows the rise of temperature of one of my transformers working respectively at 75, at 100, and at 125 periods per second. The primary and secondary virtual potential differences were measurably the same in all three cases, and in each case the same load was used, consisting of a certain number of glow lamps. The test was continued each time long enough for the transformer to attain its maximum temperature. This was taken by a sensitive thermometer, the bulb of which was placed directly on the iron, and covered by a packing of cotton waste to ensure that, as far as possible, at least the actual temperature of the iron should be indicated. Another similar thermometer was placed a few feet away to show the temperature of the room (which was fairly constant at about 60deg. F.).

The curves give the actual increments of temperature, which may be taken as some sort of measure of the relative efficiency attained. With any given output the same rise of temperature is, of course, always obtained with the same efficiency, quite apart from how the efficiency is made up. It will be observed that the lowest temperature or the highest efficiency is obtained at 100 periods; that the efficiency is lower at 125, and lowest at 75 periods.

On these lines I may suggest a method of arriving at the efficiency of transformers, which, though lacking in directness, is simple, and requires only ordinary appliances and facilities.

First run the transformer for some time in the usual way, on incandescent lamps, the output being measured. It is not necessary to make any measurements of the primary. By means of a thermometer find the rise of temperature of the transformer. Then, when the transformer has cooled down, send a continuous current through it, and measure the power in watts that raises the temperature of the whole transformer the same amount as when working with alternate currents. This takes some time to carry out; but it is accurate, and has the advantage that the lost power is measured in direct-current quantities, about which there is no question, while the power expended in the lamps, being in an inductionless circuit, is easily arrived at correctly. A wattmeter is the best instrument to use for the direct-current readings, as, on account of the rise of resistance of the conductor (which is necessarily required to carry much more than the usual current), some adjustment is necessary in order to keep the power constant, and this adjustment is effected much more conveniently with a wattmeter in circuit than if an ammeter and a voltmeter are used.

5. *Lamps, etc.*—Under this head, all apparatus for utilising or measuring alternate currents should be considered, so far as their action is affected by the periodicity. I must, however, confine myself to the lamps, which are the most important, and are the only apparatus as to which I can make any definite statements.

(To be continued.)

* The following particulars refer to conductors for primary circuits working at 2,000 volts, and show the sizes for various numbers of lamps giving a loss of 1 per cent. per mile run.

Data for copper conductors working with 2,000 volts pressure at the primary terminals of the transformers.

Transformers taken at 95 per cent. efficiency.

To allow 1 per cent. loss of pressure per mile of conductor, the primary current-density should be 450 amperes per square inch.

Conductor for any given number of 60-watt lamps.

Sectional area, in square inches = number of lamps × ·00007
Weight per mile, in lbs. = ,, ,, × 1·44
Resistance per mile, in ohms = 630 ÷ number of lamps.

The following conductors comply with the above rule, and none of them is effected by the virtual resistance effect:

Table II.

Number of lamps	B.W.G. No.	Diameter.	Sectional area.	Weight per mile.	Resistance per mile.
		Inch.	Sq. inch.	Lbs.	Ohms.
100	13	·098	·007088	144	6·3658
200	10	·134	·014102	286	3·1890
300	8	·165	·02138	433	2·1102
400	6¼	·191	·02865	578	1·5747
1,000	1	·300	·07065	1,433	0·6401

† "Formulæ for Converters," *Journal*, vol. xvii., p. 153. This paper was no doubt intended only as a mathematical investigation. It contains several assumptions that Prof. Forbes would probably not rely upon in practice.

* *Proc.*, Inst.C.E. (February 19, 1889).
† *Journal*, xviii., p. 194 (February 28, 1889).

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THE LONDON COUNTY COUNCIL.

The usual meeting of the Council of the Administrative County of London was held on Tuesday afternoon in the Council-chamber at the Guildhall, the Earl of Rosebery, the chairman, presiding.

The Highways Committee reported that they had considered the various electric lighting schemes of the present session, and in connection therewith a letter from the Board of Trade and the objections of the vestries and district boards to the several schemes. They had also had before them reports from the solicitor and Mr. T. P. Gunyon, of the Engineers' Department, on the subject. and a further letter from the Board of Trade asking for the Council's observations on Major Marindin's report of the result of his enquiry into the several applications. The committee had very carefully considered the questions relating to the future of electric lighting in London, and had embodied the conclusions at which they had arrived in the following letter, which they recommended should be approved and sent to the Board of Trade :

"Sir,—The Council has had under consideration your letter of March 13 last, in which, referring to the electric lighting schemes of the present session, you express the wish of the Board of Trade to be furnished with any observations which the Council may have to offer upon the large and very important question of the future of electric lighting in London, and you refer especially to two questions of principle which have arisen in relation to the matter—viz.: (1) What should be the extent and nature of the area to be granted ; and (2) should or should not concurrent powers be granted to two or more companies within the same area ? The Council has also considered the further letter from the Board of Trade, dated May 18, forwarding copies of a report by Major Marindin, R.E., on the result of his enquiry into the applications for provisional orders and licenses under the Electric Lighting Acts, 1882 and 1888, as well as into the subject-matter of the Bill introduced into the House of Commons by the Metropolitan Electric Supply Company.

"The Council has directed me to submit the following suggestions and observations for the consideration of the Board of Trade when dealing with the electric lighting schemes affecting the county of London :

"The Council agrees that extensive areas may properly be granted to companies when their financial and technical means of carrying out the powers entrusted to them are of a satisfactory character, and accepts generally the recommendations of the report as regards the districts to be allotted to the several companies.

"The Council considers that, in the interest of the public, competition is desirable under proper restrictions.

"The Council is not prepared to offer any opinion or suggestion with reference to the scientific or technical portion of the report, but desires to express its full concurrence with the recommendation in Major Marindin's report that a company supplying a large area without a reserve of current should be required to provide duplicate sets of generating machinery in separate buildings, and duplicate sets of mains, in order to secure a proper and continuous supply in case of a breakdown of machinery or other default, and, further, that every possible means should be taken for guarding against danger to the public from currents of high tension.

"The Council concurs in Major Marindin's suggestion (2) that certain streets should be scheduled in each district for the compulsory laying of mains, and that the supply in the remainder of the area should be made compulsory, upon requisition of consumers, on fair and reasonable conditions, and suggests that in case of such supply not being afforded after a sufficient interval of time the order should be revoked as regards the whole of the parish or district in which such default occurs. It appears to the Council that without such a provision being made a company might be in a position to supply those parts of a parish or district where there was a good demand, and to leave unsupplied those parts of the area in which the demand was limited. The Council further suggests that the companies should be required in all streets where mains are laid to bring the supply at their own cost to the consumer's premises.

"The Council concurs in the suggestion (6) in Major Marindin's report that wherever a company now supplying a district by means of overhead wires is granted an order for such area the company should be placed under statutory obligation to remove these overhead wires within two years from the granting of the order, and that, if possible, such company should be prevented from invading a district in which it has no statutory powers by means of overhead wires ; and the Council suggests that it should be an indispensable condition of the granting of any application for an order or license that in the area referred to therein all wires and mains should be laid underground.

"With reference to clause 55 of the London Company's order, which would enable the company to supply electricity to a vestry or district board for the latter to retail to consumers, the Council considers the expediency of granting such a power to be doubtful, and would suggest that, if allowed, a provision should be inserted that the power given by the clause shall in no case be acted upon without the consent of the Council having been first obtained.

"The Council also submits the following general suggestions applicable to all the orders and licenses, namely :

"(*a*) That the terms and conditions of all orders or licenses granted should be as nearly as possible identical.

"(*b*) That companies should be required not only to make use, with the consent of the Council, of subways now made, or which may hereafter be constructed, in streets where mains are to be laid, but to pay a fair rent for such use ; and, further, that in case of subways being in future made in streets where wires are already laid, the companies should be under an obligation to remove the wires into such subways, and to pay a rent for the use of them, a reasonable time (say three years), free of rent being allowed as a set-off to the cost of such removal ; that the power to make subways in the London streets should be vested in the Council, and not in the local authorities of the several districts.

"(*c*) That provision should be made to prevent the opening of any thoroughfare in the county of London for the purpose of laying mains, etc., until the consent in writing of the Council shall have been given to such opening.

"(*d*) That provision should be made for exempting the Council, and the vestries and district boards from liability in respect of any damage which may be done to mains, etc., in carrying out works of repair or improvement in streets or roads, or from the use of steam-rollers in the execution of such works.

"(*e*) That provision should be made for preventing interference with main or local sewers, or with the proper access to them, without the consent of the authorities in which such sewers are vested ; and that plans of works which would interfere with sewers in any way should be submitted for the approval of such authorities before the works are begun.

"(*f*) That, in view of the future possible reduction in the cost of production which may be made as the result of experience and invention, there should be a provision that the maximum price of 8d. per Board of Trade unit proposed to be adopted shall be subject to revision at the end of seven years ; and that, in order to ensure healthy competition between the companies during that period, (1) no amalgamation or working agreement between companies should be permitted without the consent of the Council, and (2) power should be given to the Council, at the request of a vestry or district board or on the requisition of inhabitants in any street or district, and with the consent of the company interested, to extend the area of such company to such street or district without the necessity of obtaining another order.

"That clauses should be inserted providing for the application at the end of the seven years of a sliding scale of price and dividend, on the basis of a dividend of 8 per cent., leaving the initial price and arrangement of the scale to be determined at the expiration of the term of seven years.

"That provision should be made that electricity supplied to local authorities for the purpose of public lighting shall be charged for at a less price than that charged to private consumers.

"That the minimum charge for supply should be fixed as low as possible ; and that should such minimum be fixed at £1 per quarter or over it should be reckoned by the year and not by the quarter because of the irregular requirements of the consumer at different seasons of the year.

"(*g*) That for the purposes of purchase by a public authority, any additions made to the area of supply of any company shall be taken to be part of the original area granted to such company, and that the powers over the additional area shall terminate at the same time as those over the original area, unless at the time the additional powers are granted to the company it shall be expressly stated to the contrary.

"The Council considers it would be to the advantage alike of the public and the companies that there should be one uniform system of regulation and control throughout the entire area of London. The necessity of this was forcibly illustrated by the very varied, and in many respects inconsistent, objections and requirements of the different vestries and district boards in regards to the proposed orders and by the complication and difficulty occasioned thereby.

"The Council is of opinion that, as the representative governing body of the county of London, it should be appointed the controlling authority. It would always give the fullest consideration to the representations of any local body on questions affecting its particular interests. The Board of Trade may be reminded that the main roads throughout the metropolis will shortly come under the jurisdiction of the Council, and should any general system of subways be hereafter resolved upon such system will also be under its control. The Council considers also that it should be the authority to whom should be given the power of purchase in all cases at the expiration of the specified period ; it would be manifestly impossible for any single vestry or district board to purchase a large undertaking supplying many parishes, such as that of the London or the Metropolitan Company. The Council would further suggest that if it is made the controlling authority it should be empowered to discharge the following duties—viz.: Inspection of lines and works ; testing current ; testing and certifying meters ; taking proceedings for imposition of penalties or forfeiture in cases of default as provided in the orders.

"And in order to carry out the work of testing it should be made obligatory on the companies to provide and maintain a sufficient number of testing stations, and proper and efficient testing apparatus.

"The Council, in view of the fact that some companies have been and are now supplying electricity by overhead wires without statutory powers, and being convinced of the undesirability of allowing this to be continued, would venture to suggest that in any future legislation on electric lighting the supply of electricity in any district before statutory powers have been obtained for such district should be prohibited under penalty.

"The Council, in submitting the above suggestions, is animated by a desire to facilitate the working of the companies' undertakings in the various areas to be allotted to them, and at the same time to ensure that the interests of the public are properly guarded.

"Some of the orders will affect the bridges, embankments, and other works under the jurisdiction of the Council, and the Council reserves any expression of opinion upon the manner in which its interests should be protected, as also upon other general matters of detail, until it shall have received the copy of the model order referred to in the letter from the Board of Trade of the 18th of May.—I am, Sir, your obedient servant, H. De La Hooke, clerk of the Council.

"The Assistant Secretary, Railway Department, Board of Trade."

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Mr. Haggis, in presenting the report, said the committee had taken a comprehensive view of the whole question.

Mr. Antrobus suggested, in the interests of the companies, that there should be an appeal to the Board of Trade.

Sir T. Farrer said the letter had been drafted with the very greatest care, and it met almost all the points that the Board of Trade would wish to have before it. The terms of purchase by the municipality were provided for by the Act, and with those terms the Council had nothing to do. They did not depend on the dividend paid nor the price on the Stock Exchange. He would strongly urge the Council, as far as his knowledge of the subject was concerned, to adopt the letter.

Mr. Torr opposed any appeal to the Board of Trade.

After some further discussion the letter, with a few verbal amendments, was approved, and ordered to be forwarded to the Board of Trade.

Mr. Fardell, in submitting the report of the Theatres and Music Halls Committee, said he did not approve one of the recommendations. The committee were of opinion that it was necessary, in the interest of the public safety, that there should be a periodical systematic inspection of all theatres and music-halls under the Council, and they had had before them a form of authority, prepared by the solicitor, enabling persons to enter these buildings for the purpose of inspecting them, in accordance with the provisions of the Acts of Parliament on the subject. The committee had also considered the question of the persons to whom it was desirable that this authority should be entrusted, and having regard to the duties assigned to the committee by the Council and to the large number of licensed places to be dealt with, they were of opinion that every member of the committee should be in a position to inspect at any time any of these places. They therefore recommended that the form of authority for the entry of theatres and music-halls be approved, and that a sealed copy be given to each member of the committee and also to the superintending architect and to two assistants. He objected to the form of authority being given to each member of the committee.

Mr. Marks moved the omission of those words.

After some remarks from **Captain Verney** and **Mr. Macfarlane**,

Mr. H. L. W. Lawson believed it would be absolutely futile that casual expeditions should be made by one or more members of the committee to theatres and music-halls in London, even with the best intentions in order to secure public safety and convenience.

Mr. Beachcroft agreed that there was necessity for a periodical inspection of theatres, but did not think it should be done in the way suggested.

Mr. Charrington said it could not be too widely known that they had the right and power with regard to the old theatres of having reasonable alterations made.

Mr. Clarke said the powers which the committee now sought to obtain were exercised by the police on the Continent.

Mr. Brudenell Carter held that there was no necessity for giving this power to members of the committee and making them practically inspectors of theatres.

Mr. Torr supported the recommendation of the committee.

Mr. G. W. R. Russell said it would have a wholesome influence if it were known to the managers of those premises that there was a certain number of gentlemen armed with a roving commission to visit and report on them.

Mr. N. Robinson advised the committee not to let their zeal carry them too far.

The **Rev. Fleming Williams** said there had been several attempts to reduce a serious question to the level of the ridiculous and to laugh it out as being unworthy of attention, but the people of London expected them not only to appoint a committee that should have charge of the structural adequacy of the arrangements in these theatres, but a committee that should be sensitively alive to those moral conditions that ruled them in granting licenses.

The **Chairman** said he was sorry to have to differ altogether from the last speaker and the many serious and earnest men who had taken part in the debate, but his first duty was to the Council, and he wished to point out to them that as this discussion went on it broadened out very considerably. Till the last speaker spoke they had no intimation that anything was understood except the inspection of the safety of exits. They had now suddenly had the idea that it was proposed to let loose on the theatres and music-halls of London a vigilance committee of thirty men, each of them with a passport in his pocket allowing him to go into every theatre to examine, not merely the safety of that theatre for the purposes of the public convenience, but also as to the morality of the piece. Such an idea, when once promulgated as the deliberate conclusion of the County Council, would produce a feeling of stupor throughout the whole metropolis. He pointed out that the Theatres Committee might, under the Act, surely obtain their object in another and less objectionable way, and begged the Council not to let a report go forth to London the next day that 30 of their members were proceeding about the metropolis with the right to enter any theatrical performance free at any hour and at any time. Those were the sentiments which, in deference to the wish which had always impelled him since he had occupied the chair—namely, to make the Council efficient and successful—he felt bound to express.

The amendment was adopted, and the rest of the report approved.

Mr. Foster had given notice of a motion to the effect that the chairman of the Council be requested to express to the Prince of Wales the deep regret of the Council at the personal inconvenience caused to him and the Princess of Wales at the Fire Brigade inspection on Saturday, May 25, and that a special committee be appointed to enquire into the arrangements made by the Fire Brigade Committee for the inspection of the Fire Brigade on Saturday, May 25. He said he thought the Council had learnt a lesson in making better arrangements for the future for any public function, and he therefore asked leave to withdraw his motion.

After some discussion the motion was by leave withdrawn.

Mr. Wren moved: "That it be an instruction to the Sanitary and Special Purposes Committee to take into consideration the causes of the fogs which trouble London during the winter months and the increased death-rate during their prevalence in order to put in force existing powers for dealing with them and obtaining increased powers, if necessary."

Mr. Brudenell Carter objected to the Sanitary Committee being saddled with a reference which, he apprehended, it had no power to conduct to a successful issue, and said the question could be much better considered by a special committee.

The motion was adopted, and the Council adjourned.

COMPANIES' MEETINGS.

UNITED TELEPHONE COMPANY.

The ninth annual ordinary general meeting of the United Telephone Company was held on Tuesday at the City Terminus Hotel, under the presidency of Mr. James Brand.

The **Chairman** stated that during the last few months the accounts had been subjected to very severe inspection by their two subsidiary companies, with whom, he hoped, they were now going to amalgamate, as well as by the Company's auditors. They all agreed that the Company could pay a dividend of 17½ per cent., at the same time increasing their reserve fund by about £10,000, arising from premiums on new shares issued. Their share capital was now £500,000 against £483,000 last year. As to revenue, they would carry forward £4,000 more of unearned subscriptions for the benefit of next year. To meet the wishes of many subscribers they had established an all-night service throughout the West-End of London, Chancery-lane, King's Cross, etc. So far the calls had been few, but they were gradually increasing. They had now 28 call-rooms in and about London open, and nine more would be opened very shortly. They had also concluded an arrangement with the Aerated Bread Company, which would very soon cause the opening of something like 80 fresh call-rooms in the most frequented places in London. A local exchange had been opened at Bromley, in Kent, which was now being joined to their London system by trunk. They had already an independent trunk line between London and Croydon, and a local exchange with 42 subscribers. The Brighton business in itself was, he believed, doing very well for the South of England Company, but the United Company had not had the success they had hoped for, as far as the intercommunication with London was concerned. The South of England Company had now entered into a special arrangement with them for the purposes of a call-room between London and Brighton, and they hoped to induce a large telephonic business between the two places and the intermediate towns. They had acquired space within the London Stock Exchange, and were erecting a special trunk line between the Stock Exchanges of London, Liverpool, and Manchester entirely for the use of members of these exchanges. He then referred to the action which the Company had taken against the Equitable Telephone Association and the New Telephone Company, and said he believed that in the face of the complete collapse of those companies, with a total loss of their capital, similar companies were not likely to be started during the remainder of the terms of the patents belonging to the United Company. Alluding to the question of amalgamation, he stated that the matter was first considered two years ago. By the union, difficulties and differences which now existed would be overcome, and the work would be carried out under one management. The Postmaster-General, who, in the pursuit of the duties of his office, was a very keen trader, would certainly be more able to bring his devices to pass if he had to deal with the various companies singly, and one after another, than if he had to deal with one great company, strong in unity, in financial position, and with one strong executive body. As to the reason for uniting the three companies, and under the name of the National Company, instead of the two other companies coming together under the wing of the United Telephone Company, the Postmaster-General had inclined to grant the latter permission to assign its license, on the ground, he (the speaker) understood, that the monopoly created by such a license, and by such acquiescence in their desires, would be contrary to public policy and injurious to the interests of the public by the clearing away of competition. The Postmaster-General, however, knew full well that ever since the granting of the separate license to each company there had been no competition, as each company had worked its own territory without interfering with its neighbour. As soon as they had proved that the telephone was no plaything, but was going to be a commercial success, the Postmaster-General said that, after all, the invention was only a telegraph, and that if the Post Office allowed them to use it, they must pay £10 out of every £100 gross received by them. That tax now amounted to nearly £35,000 a year; but finding that, in spite of this burden, they were getting stronger and more useful every day, the Postmaster-General pursued the old tactics placing every obstacle in the way of their progress. He concluded by moving the adoption of the report and the payment of the dividend recommended.

Mr. J. S. Forbes seconded the motion, which was unanimously carried.

Resolutions were afterwards submitted *seriatim* approving the amalgamation agreement, winding up the Company voluntarily, appointing Mr. T. A. Welton liquidator, and authorising the liquidator to carry the agreement into effect.

In answer to questions, the Chairman stated that they knew they were within the law in what they proposed, and so did the authorities

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of the Post Office. What they had done they had done most openly. The new board would consist of the present Directors of the United Company and four directors of each of the other two companies.

The resolutions were agreed to.

The following letter has been addressed by the Postmaster-General to the Secretary of the United Telephone Company:

"General Post Office, June 4, 1889.

"Sir,—The Postmaster-General has had his attention called to the notice issued by the United Telephone Company to its shareholders on the 24th ult., and to the course which the telephone companies propose to pursue with the view to an amalgamation.

"Whether such course can be legally adopted under the terms of the licenses granted by the Post Office is a question on which the Postmaster-General does not at present offer an opinion; but he desires me to acquaint you, for the information of the Directors and shareholders of the United Telephone Company, that the amalgamation of the companies was not contemplated when the licenses were issued, and that any assurances, outside the licenses, which the companies may conceive themselves to have received from the then Postmaster-General cannot be regarded as applicable to the state of things likely to result from the proposed amalgamation.—I am, etc.,

S. Arthur Blackwood.

"The Secretary United Telephone Company."

NATIONAL TELEPHONE COMPANY.

The ninth annual ordinary general meeting of the National Telephone Company was held at the City Terminus Hotel, Colonel R. Raynsford Jackson presiding.

The **Chairman**, in moving the adoption of the report, observed that they had to consider not only the ordinary business, but what was practically an amalgamation of the Company with the United and the Lancashire and Cheshire Telephone Companies. With reference to their business, in the last ten months they had had a period of prosperity. The number of subscribers had increased by 1,489, the total number now being 10,813. The mileage of the trunk wires had increased by 1,238 to 3,747, and the total mileage of their wires was now 13,583. Their gross revenue for the ten months ended April 30 had been £125,978, the increase for the ten months being £16,405. The number of exchanges had been increased by 18, making the total 135, and the call-offices by 61, making a total of 277. The net revenue for the ten months had been £42,338, and after paying the debenture interest and the preference dividends they proposed to pay a dividend for the ten months at the rate of 5¼ per cent. on the ordinary shares. It might be asked, if the Company had been so prosperous, what reason was there for amalgamating with the two other companies? After long negotiation, however, the Directors were quite satisfied that the terms which had been arranged with the other companies were fair and equitable. An amalgamation would effect a great reduction in the aggregate expenditure of the companies. They would be able to give the public a much better service all round than at present, and they would be able to meet the wants of a variety of interests which were, to a certain extent, neglected at present. It was to be remembered, also, that the National Company had been, and was, in a peculiar position in reference to the United Company, which possessed one-half of the voting powers in most of the sub-companies, the National Company among them. The sub-companies could not issue additional capital without the sanction of the United Company, and they were limited in the form of issue. By the amalgamation all these difficulties would be got rid of, and their hope was that the result of the amalgamation would be to make London the heart and centre of a huge telephonic system, embracing its own suburbs and such of the industrial towns of the United Kingdom as might desire to have a constant and easy telephonic connection with it. He thought that by giving greater facilities to the public the combined companies would do very much to popularise the telephone, and on the part of the public induce a feeling of more cordiality towards telephonic enterprise than at present existed. Colonel Williams, who had resigned his position at the Board, had issued a circular in which he had contended that the interests of the National Company had been sacrificed to those of the United Company, and arguing that the amalgamation would be received by the Postmaster-General with feelings of resentment. Quite apart, however, from the votes of the United Company the Directors' proposals were supported by a majority of more than three-fourths of the capital of the National Company. He dissented altogether from the notion that the amalgamation would be regarded as an act of hostility to the Post Office. The result of the arrangement which had been arrived at after the fullest consideration was that the United Company were to receive in the new National Company £1,250,000 of the capital, the National Company £720,000, and the Lancashire and Cheshire Company £525,000. These figures, so far as the United Company was concerned, included the value of that company's holdings in the National and the Lancashire and Cheshire Companies, amounting together to £290,625, which would have to be deducted from the total capital, reducing the capital of the three companies, as amalgamated, to, in the first instance, £2,204,375.

Mr. John Bruce seconded the motion, which was adopted, the dividends recommended being afterwards declared.

The **Chairman** then proposed the resolution, in effect approving an agreement for the amalgamation of the three companies named.

Mr. Peter Garnett seconded the motion.

Colonel Williams, who said he represented many *bonâ fide* shareholders in the Company, in the course of a long speech reiterated the statements made by him in his circular.

Mr. W. A. Smith, of Glasgow, said he represented between one-fourth and one-fifth of the independent body of shareholders, and he and those whom he represented were just as strongly in favour of amalgamation as Colonel Williams was opposed to it.

The **Chairman, Mr. Leyland** (a Director), and **Mr. J. S. Forbes** (the deputy-chairman of the United Telephone Company) also replied to Colonel Williams, Mr. Forbes observing that each of the companies was of opinion that a bad bargain had been made on its behalf. The proposed union would place them in such a position that when the time came for open competition—by the expiration of the patents—they would be able to defy not only the Postmaster-General and his department, but any outsiders.

The motion was then adopted, with one dissentient—Col. Williams—and resolutions were afterwards passed authorising the Directors to increase the capital by £3,250,000 by issuing 650,000 shares of £5 each; adopting new regulations for the Company, and, in compliance with the agreement, removing the existing Directors as from the date of the confirmatory meeting.

The **Chairman** stated that the new Board would consist of Messrs. C. S. Agnew, J. W. Batten, J. Brand, John Bruce, J. S. Forbes, Peter Garnett, E. Heyworth, F. R. Leyland, J. B. Morgan, D. Parrish, W. C. Quilter, M.P., G. H. Robertson, S. H. Sands, Colonel Jackson, and Alderman J. Thompson.

CITY NOTES.

Great Northern Telegraph Company.—The receipts for the month of May amounted to £22,800.

Direct Spanish Telegraph Company.—The receipts of this Company for May were £2,040, against £1,800.

West Coast of America Telegraph Company.—The receipts of this Company for the month of May amounted to £6,975.

Eastern Telegraph Company.—The receipts for May were £52,704, as against £49,003 for the same period of 1888, or an increase of £3,701.

Cuba Submarine Company.—The traffic receipts of this Company for May were £3,500, against £3,337. The receipts for February, estimated at £3,200, realised £3,204.

West India and Panama Telegraph Company.—The receipts of this Company for the half-month ended May 31 show an increase of £100, as compared with the corresponding period.

Lancashire and Cheshire Telephonic Exchange Company.—This Company have declared a dividend of 8¼ per cent. for the 10 months ended April 30, less the interim dividend paid in March last, £1,761 being carried to reserve.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended May 31, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £2,835.

Brazilian Submarine Telegraph Company, Limited.—The Board of this Company have declared an interim dividend of 5s. per share for the quarter ended March 24, payable on the 24th inst. The receipts of the Company for the week ended May 31 amounted to £3,960.

National Telephone Company, Limited.—This Company, in their report of the ten months ending April 30 state that the accounts are made out for a period of ten months to the above date, instead of as usual for an entire year, this change being consequent upon the proposed purchase by the Company of the United Telephone Company, Limited, and the Lancashire and Cheshire Telephonic Exchange, Limited, in accordance with agreements which will be submitted to the meeting for approval. The capital expenditure for the above period was £52,747 and the gross revenue £97,426, the amount carried forward being £63,053. The annual rentals on the 30th of April reached £121,978. There is also a revenue derived from fee messages, at the rate of £4,000 a year, making the total gross revenue reached on the 30th of April £125,978, against £109,572 for the year ending June 30, 1888. After providing for the accrued interest on the debentures, for a dividend for ten months at the rate of 6 per cent. per annum on the amount paid up on the first and second preference shares, and after having paid an interim dividend for the first half of the year at the rate of 4 per cent. per annum on the ordinary shares, there remains a balance of £15,952, out of which the Directors propose a dividend making up the distribution on the ordinary shares to the rate of 5¼ per cent. per annum for the ten months. Of the balance then remaining they propose to place £2,500 to the reserve fund and to carry forward £2,765.

NEW COMPANIES REGISTERED.

Electric Construction Corporation, Limited.—Registered by Linklater and Co., 2, Bond-court, Walbrook, E.C., with a capital of £500,000 in £10 shares. Object: to adopt an agreement with reference to the sale and purchase by the Company of certain business patents; to carry on the said businesses, and to construct, contract for, establish, carry on, or to finance upon expedient terms for other companies, firms, corporate or municipal bodies, to enable them to establish machinery for lighting streets, public and private buildings and premises of every kind by electricity, either alone or in conjunc-

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tion with other means, and for any purpose of light, heat, electric, magnetic or other force. The first subscribers are :

	Shares.
Sir C. Fox, Coombe Spring, Kingston-on-Thames	1
Sir D. Cooper, Bart., 6, De Vere-gardens, W.	1
J. Pender, Thornley Hall, Rugby	1
Sir H. C. Manse, Manora, Bedford	1
J. Verity, King-street, Covent-garden	1
J. I. Courtenay, 1, Essex-court, Temple, E.C.	1
J. Smith, Oakeswell Hall, Wednesbury	1

There shall not be less than three nor more than 15 Directors. The first to be appointed by the subscribers to the memorandum of association. Qualification, £1,000 stock. Remuneration, £3,000 per annum, and, in addition, £250 for each Director over 11, and an additional £1,000 for every 1 per cent. profit after 10 per cent. dividend. Such remuneration to be exclusive and in addition to the remuneration payable to J. Smith and T. Parker, as managing and works Directors.

Halifax and Bermudas Cable Company, Limited.—Registered by Saxelley and Faulkner, 7 and 8, Ironmonger-lane, E.C., with a capital of £50,000 in £5 shares. Object : to establish, maintain, and work lines of telegraphic communication between Halifax, Nova Scotia, and the Bermudas. The first subscribers are :

	Shares.
E. A. Field, 8, Oxford-terrace, W.	1
S. Johnson, 9, Inverness-terrace, Hurlingham	1
J. Whitaker, 11, Benedict-road, Brixton	1
J. Yorn, 59, Blackheath-road, S.E.	1
N. Cassell, 41, South-hill-road, Hampstead	1
W. Daniells, 20, Granville-square, W.C.	1
W. Pitt, 39, Sandbrook-road, N.	1

There shall not be less than three nor more than seven Directors ; the first to be appointed by the subscribers to the memorandum of association. Qualification, £500 stock. Remuneration : Chairman, £300 ; other Directors £200 per annum.

Woking Electric Supply Company, Limited.—Registered by Bircham and Co., 46, Parliament-street, S.W., with a capital of £20,000 in £5 shares. Object : the construction of works, machinery and apparatus for lighting streets, etc., by electricity. The first subscribers are :

	Shares.
E. Stevenson, 38, Parliament street, S.W.	1
J. Mackenzie, 15, Great George-street, S.W.	1
H. S. King, Founders' Hall, E.C.	1
E. Maunce, 46, Parliament-street, S.W.	1
S. Chadwick, 17, Spencer-street, S W.	1
S. Bircham, 46, Parliament-street, S.W.	1
E. Price, 15, Holderness-road, Tooting	1

There shall not be less than three nor more than five Directors. The first are H. C. Masterman, E. Stevenson, S. C. Phillips, A. G. Gale, and H. S. King. Qualification, £100 stock.

Portsmouth and South Hants Electricity Supply Company, Limited.—Registered by C. Doubble, 14, Serjeant's-inn, E.C., with a capital of £50,000 in £5 shares. Object : to form centres in Hants, at which electric power may be generated or accumulated, and from which the same may be distributed for the purpose of lighting private houses, or street lighting, etc. The first subscribers are :

	Shares.
Colonel C. L. Owen, J.P., Portsmouth	5
R. Ford, Portsmouth	5
W. Edmonds, Annesley House, Southsea	5
H. Holbrook, Holmwood, Southsea	5
A. White, North End, Portsmouth	5
R. Hammond, 117, Bishopsgate-street, E.C.	5
Colonel Mumby, Spring-gardens, Gosport	5

The number of directors shall not be less than four nor more than nine ; the first to be appointed by the subscribers to the memorandum of association. Qualification, 50 shares. Remuneration, £400 per annum, with additional $\frac{1}{15}$ on all profits after 5 per cent. dividend, divisible as they determine.

PROVISIONAL PATENTS, 1889.

MAY 27.

8697. **Improvements in electric musical mechanism.** Stanley Herbert Gibson, 34, Southampton-buildings, London.

8709. **Amalgamating gold by electricity and mechanical motion.** Emile Hippolyte Marie Andreoli, 62, Loughborough-park, Brixton.

8769. **Improvements in electrical measuring instruments.** Arthur Cecil Cockburn and John Nealor Cooper, 32, Gaisford-street, Kentish Town-road, London.

8776. **A combined postal, electric signal alarm and telephone pillar.** Edward Hasselbach, Maurice Henry Hyman and Jacob Alexander Alexander, 55 and 56, Chancery-lane, London.

8780. **Improvements in electrical switches.** Edouard Emmanuel de Facien, 33, Chancery-lane, London.

8793. **Improvements relating to screw-cutting lathes and to electrical indicating apparatus for use in connection therewith.** William Howard Winnall, 4, South-street, Finsbury, London.

8800. **Improvements in regulators chiefly designed for use in electric arc lamps.** Henry Harris Lake, 45, Southampton-buildings, London. (Otto Heinrich Louis Lindemann, Germany.)

MAY 28.

8815. **Improvements in devices for automatically interrupting an electric circuit under predetermined conditions.** William Phillips Thompson, 6, Lord-street, Liverpool. (The Westinghouse Electric Company, United States.)

8855. **Improvements in secondary batteries or accumulators.** Thomas Harris and Henry Francis de Bathe Cameron, Detroit, Michigan, United States. (Complete specification.)

8861. **Improvements in electric switches.** Oliver Imray, 28, Southampton-buildings, Chancery-lane, London. (Walter Thompson, United States.) (Complete specification.)

MAY 29.

8905. **Receiving and transmitting an electric current for telephonic, telegraphic, or other electrical purposes, viz., "The anti-alternate current relay."** Alfred George Burrell, 5, King-street, Sheffield.

8925. **Improvements in electric batteries.** Charles Wells, 22, Southampton-buildings, Chancery-lane, Middlesex.

8944. **Improvements in electrical switches or commutators.** Douglas Clavell Bate, 6, Derwent-grove, East Dulwich.

8958. **An electric meter.** Alphonse Frager, 28, Southampton-buildings, Chancery-lane, London.

MAY 30.

8979. **Improvements in electric switches.** Frederik Vilhelm Andersen, 3, Elm-court, Temple. (Complete specification.)

8986. **Improvements in secondary batteries.** David Urquhart, William Bates, and Frank Wynne, 11, Victoria-street, S.W.

8999. **Improvements in electrical tramways or railways and apparatus therefor.** John Hopkinson, 47, Lincoln's-inn-fields, London.

9013. **Improvements in arc lamps.** Thomas Stanley, Alfred Henry Davies and John Joseph O'Connor, 8, Quality-court, London.

MAY 31.

9034. **Improvements in self-contained dome electric bells.** Wm. Pressland and William Thomas Pressland, 4, Little Moorfields, London.

9066. **Improvement in railway fog signals—viz., "The electric fog signal."** Edgar Alexander Harvey and Martin Edward Brooke, Brookdale, Lindley-road, Leyton, Essex.

9074. **Improvements in the electric ignition of gas.** Richard Warwick, 20, High Holborn, London.

JUNE 1.

9093. **Improvements in storage batteries.** August Jung, 6, Lord-street, Liverpool.

9096. **Improvements in telephonic switch boards.** Hubert Fielden Jackson and Daniel Sinclair, 62, St Vincent-street, Glasgow.

9119. **Improvements in electric bells.** Edward Thomas Fiford, 21, Cockspur-street, London.

9133. **Improvements in the manufacture of carbons or electrodes for electric lamps.** Henry Harris Lake, 45, Southampton-buildings, London. (Messrs. Lacombe and Co., France.)

SPECIFICATIONS PUBLISHED

1887.

14542. **Electric motors.** Sandwell. (Reprints with alteration.) 11d.

1888.

6893. **Electro generators** Walker. 8d.

6985. **Electrical tramcars.** Immisch. 11d.

9046. **Magneto-electric bells.** Cox-Walker and Swinton. 8d.

9825. **Electrical switches.** Mackie. 8d.

9907. **Electric current and tension meters.** Dolivo-Dobrowolsky and Others. 8d.

9910. **Dynamo-electric machines.** Kapp. 8d.

10782. **Electric meter.** Miller. 8d.

10887. **Electric cartridges, &c.** Day. 11d.

11544. **Electrical coin-freed machines.** Cumming. 1s. 1d.

18494. **Galvanic batteries, &c.** Roberts and Brevoort. 8d.

1889.

5176. **Electrical installations.** Sperry. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3½
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main	1	⅜
27 July	10/0	India Rubber, G. P. & Tel.	10	19½
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply	5	3¼
......	...	Swan United	3½	2
12 July	12/0	Telegraph Construction	12	42½
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15½

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NOTES.

A New Cable.—Advices from Brussels state that it is proposed to lay a telegraphic cable from Ostend to America.

Brazil.—The Brazilian Government are prepared to receive tenders up to October 30 for the laying of one or more submarine cables between Brazil and the United States of America.

Electric Lighting in France.—The town of Louhans (Saône-et-Loire) will be lighted by the firm of X. Garnot, of Paris, from the first of next October. The concession is for 20 years.

The Phonograph.—It is stated that Edison has made a discovery in relation to the coating of the phonographic cylinder which will materially improve the quality of enunciation.

A Train Struck by Lightning.—On the 23rd of last month a train on the line from Utiel to Valenza was struck by lightning. One of the cars was wrecked. No deaths are reported.

Electric Sugar.—The "electric sugar" case is now being heard, the Rev. W. E. Howard, father-in-law of Prof. Friend, now being on trial in Part 1 of the New York Court of General Sessions.

Electric Light and Insurance.—There are 1,300 buildings in Philadelphia furnished with electricity for light or power purposes, and on not one of these has there been any loss by fire for two years past.

Going Ahead.—It seems only yesterday that we heard of the rush to Oklahoma, and now we hear of the Mayor being instructed by the Council to appoint a committee of three to consider the question of electric lighting.

French Omniboats.—The omniboats plying on the Seine in connection with the Exhibition have each received an installation consisting of a small 5-h.p. engine and a Breguet continuous-current dynamo. These serve 17 incandescent lamps, conveniently arranged in the cabins, the engine-room, etc.

Busy.—The New York *Electrical World* is informed that Mr. Harold P. Brown has been quite busy making arrangements to supply the State authorities with the apparatus needed for electrical execution. Fortunate Mr. Brown. We hear that the date of the much talked of execution has been postponed.

Printing by Electricity.—The printing presses of the *Chronicle*, published at Spokane Falls, Washington Territory, has been run by a 2 h.p. Sprague motor for over a year. The proprietors say that during this time the motor has not cost them one cent for repairs, and is in as good a condition as when installed.

Elwell-Parker's.—We are informed that Elwell-Parker, Limited, had just acquired for their new electric engineering works a site of not less than 24 acres, at Bushbury, a village two miles from Wolverhampton, on the way to Penkridge. Under the new arrangement it is to be presumed that the site will be taken over by the Electric Construction Corporation, Limited.

Proposed Lighting at Mannheim.—The municipal authorities at Mannheim have been considering the question of electric lighting, and Mr. Uppenborn and Prof. Kittler were instructed to furnish independent reports as to the advisability of establishing a central station. Both reports are in favour of the project, but it is recommended that the works be at first carried out experimentally.

Capital Punishment in France.—It is now proposed to abolish the guillotine, and subtitute death by electricity for the capital punishment in France. It is pleasing to think that there may be a fund of truth in the oft-repeated assertion that "electricity is life," but we must confess to a feeling of horror that the heavenly fluid should be made to fill the base offices of executioner.

Zigang's Telephone.—The principal point in connection with Capt. Zigang's electromagnetic telephone seems to be his discovery "that when a telephonic membrane is acted upon by an undulating current through the intermediary of an electromagnet the currents obtained are, up to a certain limit, more intense and more distinct, as the size of the membrane is limited and its elasticity increased." The apparatus is constructed in conformity with this theory, and is said to possess an advantage over magnetic telephones in that it is less affected by induction currents from neighbouring wires.

Interesting Papers.—Some interesting papers have recently been read in America. Among them may be mentioned the following: "Electric Motor Regulation," by Francis B. Crocker; "The Efficiency of the Arc Lamp," by Hatsune Nakano, being a note on Mr. Ernest Merritt's paper on "Some Determinations of the Energy of the Light from Incandescent Lamps"; "Magnetism in its Relation to Induced E.M.F. and Current," by Prof. Elihu Thomson; "The Spiral Coil Voltameter," by Harris J. Ryan; and "On Modern Views with Respect to the Nature of Electric Currents," by Prof. H. A. Rowland.

Ship Lighting.—The installation on board the new twin-screw steamer "Augusta Victoria," running between Hamburg and New York, is said to be exceptionally well arranged. The plant consists of four Schuckert dynamos, driven by four Vulcan engines, supplying 800 16-c.p. Siemens and Halske lamps distributed throughout the vessel. In the dining-saloon are a great number of small electroliers, each holding three lamps of opalescent glass Each cabin is provided with a single lamp encased in a cream-coloured globe, giving it much the appearance of a miniature arc lamp. The dynamos give 300 amperes and 60 volts at a speed of 450 revolutions per minute.

The Lighting of Weybridge.—The lighting inspectors, in view of the number of promises of support which have been received, have invited tenders from some of the principal electricians in the country. We understand that amongst them Mr. Kenneth Mackenzie, A.M.I.C.E., M.I.E.E., the engineer of the Woking Electric Supply Company, has been asked to tender, it being stated that the estimated demand would be for about 100 street lamps and 800 inside lights. We believe that, as an alternative scheme, Mr. Mackenzie will suggest that mains should be laid from Woking to Weybridge (a distance of six miles), and the light supplied from the works, which are to be forthwith commenced at Woking.

Another New Cable.—We are informed that the Telegraph Construction and Maintenance Company has signed a contract for laying a direct cable from Europe to Buenos Ayres. The Government of the Republic guarantees five per cent. to the shareholders. The number of messages now sent through the Brazilian Submarine and

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the Western Brazilian to the territory of the Republic is said to be sufficient to pay at least four per cent. on two millions sterling. A new company will be started to take up the contract. The Telegraph Construction and Maintenance Company will be the vendors, and Sir John Pender the chairman. Why! Certainly! When this company comes out we shall have something to say about it.

Progress in Australia.—Advices from Sydney, New South Wales, state that at a meeting of the Balmain Council, held in April last, it was agreed to accept Mr. Montague Rhys Jones's offer to construct an electrical tramway at Balmain. The concession will be in force for a period of 21 years, at the expiration of which time the Council has the power of purchase. Mr. Jones, who is one of the firm of Messrs. M. R. Jones and Co., engineers and contractors, of Sydney, has deposited £1,000 as a bonâ fide for the fulfilment of the contract, and is prepared to commence the work within a month. The route of tramway will begin at the Darling-street wharf and terminate at the municipal boundaries of Balmain and Leichhardt at Callen Park, a distance of about two miles.

Gas versus the Arc Light.—We quote the following paragraph from an interesting letter from the late Sir Charles William Siemens, recently published: "A very powerful arc light gives as much as 33 per cent. of the energy absorbed in the arc as luminous rays (or 25 per cent. measured horizontally), whereas Tyndal found a vivid gas-flame to yield $\frac{1}{25}$th of its radiant energy as luminous. But the $\frac{24}{25}$th is the loss only by invisible rays, and does not include the heat carried up through the chimney as heated air, which loss is not an invariable quantity, but amounts to at least four times the radiant heat. This makes the total heat developed in combustion of the gas $25 \times 4 = 100$ times greater than that sent out in the form of luminous rays.

A Little Ahead of the Times.—In an editorial, the New York *Sun* says that no fewer than four inventors of experience, backed by substantial capital, are striving to perfect systems of electric long-distance rapid transit. The prize is great, and it lies in plain sight. The main idea—namely, that small packages, if not general merchandise and passengers, may be conveyed at a speed varying from 100 to 200 miles an hour—is accepted by practical electricians as sound in theory and easy of application. The difficulties are merely those of detail. True, the difficulties are merely those of detail, but we imagine some considerable time will elapse before those details will work down to practice. One hundred miles an hour is not a very high rate of speed, but we question if 200 miles an hour would be comfortable travelling.

To Indicate Shoals.—An electrical instrument for indicating the presence of shoals has recently been invented. The apparatus consists of a strong cylinder filled with shot, so that when hung by a cable from a ship it will remain perfectly upright in the water. Embedded in its centre is an insulated tube half full of mercury, the two ends being closed by metallic plates, which are in communication, by insulated wires carried by the cable, with an electric battery and bell on the deck of the ship. The action of the apparatus is as follows: When the vessel approaches shallow water the cylinder drags on the ground below, and is consequently no longer upright, but is thrown on its side. This causes the mercury in the tube to touch both the metallic plates attached to that tube, as above explained; the electrical circuit thus becomes complete, and the warning bell on the ship instantly rings.

The Thomson-Houston Electric Railway in Boston.—The following report for April, of the Cambridge Division of the West End Street Railway, Boston, Mass., is of interest, and shows that the electric railway can be depended upon. This road has a previous record of but nine trips lost out of 1,179.

Average number of motors in daily service	8
Round trips of motor cars	2,720
Time in service, motor cars	3,232 hours.
Mileage of motor cars	17,680 miles.
Round trips, one tow car	2,720
Round trips, two tow cars	226
Time in service, towed cars	3,500 hours 30 mins.
Mileage of towed cars	19,149 miles.
Total round trips	5,666
Total car mileage	36,829

Of the above round trips but seven were lost.

Royal Meteorological Society.—At the ordinary meeting of this society, to be held by permission of the Council of the Institution of Civil Engineers at 25, Great George-street, Westminster, on Wednesday, the 19th inst., at 7 p.m., the following papers will be read: "The Climate of British North Borneo," by Robert H. Scott, M.A., F.R.S.; "On the Variation of the Temperature of the Air in England during the period 1849 to 1888," by William Ellis, F.R.A.S., F.R.M.S.; "Atlantic Weather and Rapid Steamship Navigation," by Charles Harding, F.R.M.S.; "Meteorological Phenomena observed during 1875-87 in the neighbourhood of Chelmsford," by Henry Corder; "Rainfall in China, and Meteorological Observations made at Ichang and South Cape in 1888," by W. Dorberck, Ph.D., F.R.M.S. In addition to the above papers, Mr. Marriott will make a communication on the recent thunderstorms, and a number of photographs of lightning will be exhibited.

Bichromate Batteries.—From some late experiments with bichromate cells without diaphragms it has been concluded that a useful form is that where the cells have a height greater than their diameter, and contain about six litres of a solution of 12 parts of bichromate of sodium in 100 parts of water, to which 25 parts of sulphuric acid has been added. If one square dm. of zinc is exposed to the solution, it will not need to be changed for two hours. Owing to their very low internal resistance, these cells can be conveniently used for working glow lamps coupled in parallel. On account of the small quantity of material required, the difficulty of crystallisation, and the low price of the material, the bichromate of sodium is to be preferred to the potassium salt or to chromic acid. The depolarisation and E.M.F. is greater with porous carbon than with hard close-grained carbon. The zincs used should be free from carbon and iron, since, if the cells are coupled in parallel, local action may be set up.

Electric Lighting in Paris.—The Société Popp has finished the installation of the light in the main boulevards. The Thomson-Houston arcs, to the number of 44, are placed 40 metres apart, and are supplied by a Thomson-Houston dynamo of 2,500 volts and 30 amperes, excited by a Gramme machine. The cables are doubly insulated with indiarubber and guttapercha, and have been encased in lead before being laid in the conduits. The Continental Edison Co. are nearing the completion of their section, but the lamps (38 Pilsen arcs) are said to be very ugly. Edison dynamos are of course used, and these

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are driven by engines of 1,300h.p.; steam being supplied from four Babcock and Wilcox boilers and four Belleville generators. The Electrical Society for the Transmission of Power will furnish the lighting on the boulevard from the Porte St. Denis to the Place de la République. They have arranged a station with four 200-h.p. engines supplying 25 arc lamps. A sum of 200,000f. is to be allowed to the three companies for the lighting of the boulevards, or at the rate of about 50,000f. per kilometre per annum.

Gaselectrics.—We formally lay claim to the invention of this word, a word which is every day becoming more necessary as the definition of a mixed industry. Gaselectrics is that branch of commerce which formerly relied for its returns upon gas, but which has now weakened, and sought to prop itself with the electric fluid. We do not anticipate more than an ephemeral existence for our bantling. In the natural order of things it will lose its first syllable, and we don't care how soon the dismemberment commences. Gaselectrics is just now in full swing in Paris. La Société Technique de l'Industrie du Gaz en France is holding its annual congress. Here is a specimen of the programme: On Wednesday M. Monnier discoursed upon "electric mains, and a visit to the central electric lighting station in the Palais Royal." On Thursday M. Lechatelier took as his subject "Pyrometrical Apparatus"; M. Hospitalier reviewed "Electric Meters," and the morning of the 15th will be devoted to an inspection of the electrical section of the exhibition. Among the papers already announced to be read are a number dealing with electrotechnics.

Leeds.—A correspondent of the *Leeds Mercury* thinks that the Electric Lighting Committee should not be blamed for the delay in deciding what they shall recommend to the Town Council, for the reason that until the last two years central station lighting has not in this country been a very marked success. "I am satisfied," says the correspondent, "looking at the names of the gentlemen on the Lighting Committee, that they will bring a common-sense business view to bear on this subject, and after taking care to inform themselves thoroughly of what are the most successful installations, will recommend what in the interests of true economy (taking efficiency and cost together into consideration) will be the best for the town. I was told the other day that the Brighton installation had been running for several years without a single breakdown, and probably there are other cases in which an equally good record can be given. Now, we have waited so long, and the committee are understood to be prepared to report, I should hope that the Council will not delay the carrying out of their recommendations as quickly as possible, or else the winter will be upon us again before anything is done."

Electrical Plumbing.—The extensive adoption of lead-coated cables for subway electrical lines has given birth to an occupation which is in some sense a new trade—the electrical plumber. The subway cables have to be joined at frequent intervals, at the least at every second manhole. In uniting the ends, the skill of both electric lineman and plumber is required. A cable may contain a hundred or more wires, which may be grouped in pairs to add to the complexity. To join such a cable the wires have to be properly connected with each other, each splice has to be carefully insulated with tape or equivalent wrapping, and finally a sleeve is slipped over the joint and secured by two wiped joints. At this point the lineman has to change his trade and become a plumber, when he "wipes" the joints at each end of the sleeve, so as to protect the wires perfectly from moisture. Much other work falls within his scope. Lateral connections have to be made. One or more wires have to be picked out and led to one side or the other on new routes. As the system grows in extent, so will his work increase in complexity. In fact, what is to some extent a new trade has been created.

Birmingham Electrical and Industrial Exhibition.—We hear that the space for the exhibits in the International Electrical and Industrial Exhibition, to be held in Bingley Hall this year, has all been taken up, and that the preliminary arrangements have been settled in a most satisfactory manner. The original dynamo, or electro-depositing machine, which will be shown in the exhibition, was invented by a Birmingham man, and built in the works of Messrs. Prime and Sons, the well-known electroplaters. An interesting collection of electric lighting apparatus, including one of the early incandescent lamps, is being sent over by Dr. Woodward, of Toronto, who was born in Birmingham. It is said that Dr. Woodward's inventions were sold to Mr. Edison at the time he commenced to bring out the system of lighting which has since become so popular. The contract for erecting the boilers, engines, and other foundations, the orchestra, and the general works connected with transforming Bingley Hall into a fitting home for the exhibition, has been let to Mr. John Parkes, Conybere-street, and the works will be pushed forward with all possible despatch. It is intended to open the exhibition on Thursday, August 1, and arrangements have been made with the leading railway companies in the kingdom to run excursion trains at frequent intervals, to give an opportunity for people at a distance to visit the exhibition at a low charge.

Electric Traction.—The city of Newburyport, Mass., is to have an electric street railway. Similar enterprises are on hand for Pittsburg. St. Louis has also applied for an electrical railway franchise, and the Decatur, Ill., road is now being equipped. A notice from Pierce City, Mo., states that it has become evident to all street railway men that animal power has had its day. A director of the Metropolitan Street Railway Company, which operates more than half the street railway mileage in Pierce City, said that before their last cable line was half completed the Board regretted its decision, and was sorry it had not awaited developments in electricity. The company have let a contract to equip two miles of one of their horse car lines with electricity, and will thoroughly test the system. The line between Beverly and Danvers will probably be finished by the 15th proximo. The Colerain road near Cincinnati will also be opened on the same day. The contracts for the construction of the Alameda-avenue electric railway in Denver, Col., were recently signed by the Thomson-Houston Electric Company, and grading will be commenced at once. The cost of constructing the entire road, which is three and a half miles long, will be 40,000dols. The agreement calls for the line to be in working order by August 15th. Other reports from America are equally satisfactory, but it would take up too much space to enumerate them in detail.

Reading.—At a meeting of the Reading Town Council held on the 6th inst. it was proposed and carried, "That it is advisable that arrangements should be made as soon as practicable for lighting by electricity throughout the whole night such a district as it may be possible to light

satisfactorily with 30 electric lamps, and that the Highways, Streets, and Public Lights and Gas Committee be authorised, subject to the approval of the Council, to arrange with Messrs. Laing, Wharton, and Down, the electrical engineers, accordingly." Mr. Dodd, the proposer of the resolution, said that the sooner they took the question of electric lighting into consideration the better. He had formed the opinion that the electric light recently shown in the town was very desirable indeed for public lighting, and also that its quality was steady and bright, the only fault he could find being that the lamps were hung rather too high. Messrs. Laing, Wharton, and Down's estimate of the cost was based upon the gas lighting being exactly as it was at the present time. If they raised the burners to 5ft., the expense of the two systems would be about the same. The real question was whether the town should be lighted as it had been in past years, or whether they thought this new light, which was becoming universally used in America and all over Europe, and which was to be the light of the future, should be introduced into Reading, while not altogether displacing the gas company.

Utilisation of Electrical Energy in Hungary.—Three installations recently put down by Ganz and Co., of Buda-Pesth, are, owing to their practical character, of some interest. One is at the paper-mills of Mr. Kapferer, at Wattenser, and consists, briefly, of a turbine of 60 effective h.p., driven by a waterfall, near Innsbruck. The current from the dynamos (E.M.F. 500 volts) is conveyed by aerial lines of a length of 0·62 mile to a motor of 50 effective h.p., which in turn drives the paper-making machinery. The installation in the neighbourhood of Neustadt-Vienne is especially interesting, illustrating, as it does, the simultaneous distribution of electricity for light and power by means of alternating currents. In this instance, also, water power is utilised, and a brewery is supplied with 200 lamps and sufficient power to work the various machines used in the establishment. Two 10 h.p. and one 5 h.p. motors are used. The generator is a Ganz alternate-current dynamo of improved construction (type A), giving 50 kilowatts (25 amperes and 2,000 volts) at 500 revolutions per minute. Each of the 10 h.p. motors runs at 830 revolutions per minute, and the 5 h.p. at 1,250. The distance between the generating dynamo and the motors is about a mile and a half. We believe that this installation was to some extent an experimental one. It has been, it would seem, successful, and Mr. Max Bernd, who claims that this is the first practical application of a system of distribution over long distances, and by the same circuit for both power and light, by the Zipernowski-Deri-Blathy transformers, is to be congratulated. The third installation is at the sawmills of Mr. Glesinger, at Furtschek, near Kremnitz, and is an example of direct distribution for power and light. The lighting consists of 50 incandescent and two arcs differently divided. A motor of 3·5 h.p. serves to revolve a drum, by means of which, and a rope wound upon a drum, a truck runs to and fro between the works and the railway station, carrying loads of cut timber.

Company Promotion or Progress?—Within the last few days we have had the Electric Construction Corporation, Limited, upon whose proceedings we are keeping an eye, and Elmore's Foreign and Colonial Patents Copper Depositing Syndicate, the latter being an outcome of Elmore's Patent Copper Depositing Company, Limited, which was formed a few years ago for the purpose of exploiting Messrs. Elmore's English patents for the manufacture of copper articles direct from rough copper bars. Another scheme on the *tapis* is the Municipal Electric Light and Power Corporation, Limited, particulars of which will be found elsewhere in our columns. Yet another is the amalgamation of the Woodhouse and Rawson Companies, which may be looked for in the course of the next few days. As a matter of fact, the parent Elmore Company and the bantling syndicate are both in the hands of Woodhouse and Rawson, and we hear that outside of this triangular promotion they have other irons in the fire. We are asked to state that the shares of "Elmore's Foreign and Colonial Patents Copper Depositing Syndicate, Limited," have been over-applied for, and now stand at $1\frac{1}{16}$ premium. It seems to us incredible that people should be so foolish as to put their money into a concern of this kind. We should have thought the speculative character of the enterprise would have been apparent to the most casual observer. Let us put the matter clearly. The syndicate is formed, with a capital of £120,000, to retail the foreign and colonial patents (many of which are *only applied for*) to the highest bidder. The prospectus leads us to infer that advantageous offers for these patents have already been received. If that is so —seeing that the sale of patents requires no expenditure of capital—why are Messrs. Woodhouse and Rawson so anxious to give away a good thing? Why ask the public for money? As a matter of fact, we believe that Woodhouse and Rawson bought these patents for £37,250, payable as to £11,000 in cash, whereas they are to receive £110,000 for them from the syndicate. Of this latter amount, £80,000 is payable in cash. Messrs. Woodhouse and Rawson's profit would then be £69,000 in cash, besides £3,750 in shares. No doubt this may be a good and sufficient reason for the formation of the syndicate, but we fail to see how it justifies the demand made upon the public.

The Vestries and Electric Lighting.—On the 5th inst., at their fortnightly meeting, the St. Saviour's Board of Works went into the question of electric lighting. The Clerk laid before the Board a communication from the Board of Trade relative to the provisional orders in respect to electric lighting. The Board intimated that they would be guided to a great extent by the views of the local authorities. Mr. Haggis, C.C., remarked that the matter was very pressing. The provisional orders for the companies were not yet framed, and it was desired to pass them during the present session. The County Council considered the matter on the previous day, and the report of their committee would be forwarded immediately to the Board of Trade. The Board wished to compel the companies to lay mains in certain streets, and it would be as well to act expeditiously in the matter. The matter was referred to the Paving Committee for consideration, with power to act.—At the last meeting of the Rotherhithe Vestry, a letter with regard to the electric light was referred to committee, with the object of selecting streets to be scheduled wherein mains must be laid within a stipulated time.—At the meeting of the Newington Vestry, upon the recommendation of the Works and Sanitary Committee, it was resolved that the Board of Trade be asked to include this parish in the provisional order to be granted to the London Electric Supply Corporation.—At Blackpool, Mr. Councillor Eaves called attention to the paragraph relating to the estimate for gas revenue, etc.,

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account, and asked whether the estimate provided for two electric lights to the north of the North Pier. Mr. Alderman Hall replied that the estimate was not before the Council. It would be laid before the Finance Committee, with the estimates of other departments, and that would be the time to discuss it.—At the last meeting of the Holborn District Board, a letter was received from the secretary to the Board of Trade stating that the companies supplying electricity in the metropolis should be compelled to lay their mains within a specified time in the list of scheduled streets, and in the determination of this list the Board would be largely guided by the views of the local authorities; therefore they would be glad to receive from them at the earliest opportunity a list of the streets which in their opinion should be scheduled. The communication was referred to the Works Committee for consideration and report.

Reception of and Dinner to Prof. Elihu Thomson.—Among the many men of eminent scientific ability and attainments now visiting this country from the United States, one of the most distinguished must be considered to be Prof. Elihu Thomson, president of the American Institute of Electrical Engineers, member of many other learned societies, and the moving spirit of the Thomson-Houston Electric Company. The close affinity of the Laing, Wharton, and Down Construction Syndicate with the Thomson-Houston Company (its *raison d'etre* being the extension of the Thomson-Houston system of lighting), rendered it natural that they should seek to welcome the professor on his arrival in England, and this welcome took the form of a reception and dinner on Wednesday evening at The Ship Hotel, Greenwich. Colonel Martindale, C.B., late R.E., the chairman of the Finance Committee of the syndicate, occupied the chair, and was supported by Mr. Percy Westmacott, Dr. Merz, and Mr. Crewdson, members of the committee, and by Messrs. Wharton, Down, and Davies, the syndicate's expert managers, and Mr. Warine Martindale, the secretary. Among the guests met to do honour to the professor were: Sir William Thomson, F.R.S., Sir Frederick Abel, C.B.; Profs. George Forbes, John Perry, Silvanus Thompson, Ayrton and Hughes; Captains Candee and Holden; Doctors T. A. Fleming and W. Lant Carpenter; Messrs. J. T. Moulton, Q.C., M.P., R. W. Wallace, J. T. Bottomley, Bellani, A. E. Baines, A. Carey, C. H. Davies, Killingworth Hedges, Musgrave Heaphy, C. H. Gimingham, H. F. Kite, A. Margary, H. G. Massingham, John Moore, J. F. Meech, W. Lake, H. Lake, C. W. Price, C. E. Spagnioletti, J. W. Swan, W. H. Snell, W. Shapton, R. H. Tweddell, J. B. Verity, J. E. Wright. Some others of our leading electricians were unable to accept the syndicate's invitation. The professor was received on his arrival by a few words of welcome from the chairman, who was followed by Sir William Thomson, Sir F. Abel, and Mr. Swan. After a brief reply from the professor, the company proceeded to dinner, to which about 46 sat down. The toasts proposed by the chairman were the "Queen," the "President of the United States," "Prof. Elihu Thomson"; "Prosperity to the Thomson-Houston System," was given by Dr. Merz; and "Our Guests," by Mr. Wharton. The professor returned thanks. Mr. Meech, of the Thomson Houston Company, replied on their behalf; and Mr. Moulton, Q.C., for the guests. The reception and dinner may be taken as an honour justly due to Prof. Elihu Thomson, and as constituting another link in the chain of friendship which is binding ever closer together individuals in the two countries, and thus the two countries themselves.

The Phenomena of Conduction.—Prof. H. A. Rowland remarks: "The invention of the telephone, by which sound is carried from one point to another by means of electrical waves, has forced into prominence the subject of these waves. Furthermore, the use of alternating currents for electric lighting brings into play the same phenomenon. Here, again, the difference between a current of water and a current of electricity is very marked. A sound wave traversing the water in the tube, produces a to-and-fro current of water at any given point. So, in the electrical vibration along a wire, the electricity moves to and fro along it in a manner somewhat similar to the water, but with this difference: the disturbance from the water motion is confined to the tube, and the oscillation of the water is greatest in the centre of the tube, while, in the case of the electric current, the ether around the wire is disturbed and the oscillation of the current is greatest at the surface of the wire and least in its centre. The oscillations in the water take place in the tube without reference to the matter outside the tube, whereas the electric oscillations in the wire are entirely dependent on the surrounding space, and the velocity of the propagation is nearly independent of the nature of the wire, provided only that it is a good conductor. We have, in the case of electrical waves along a wire, a disturbance outside the wire and a current within it, and the equations of Maxwell allow us to calculate these with perfect accuracy and give all the laws with respect to them. We find that the velocity of propagation of the waves along a wire, hung far away from other bodies and made of good conducting material, is that of light, or 185,000 miles per second, but when it is hung near any conducting matter, like the earth, or enclosed in a cable and sunk into the sea, the velocity becomes much less. When hung in space, away from other bodies, it forms, as it were, the core of a system of waves in the ether, the amplitude of the disturbance becoming less and less as we move away from the wire. But the most curious fact is that the electric current penetrates only a short distance into the wire, being mostly confined to the surface, especially where the number of oscillations per second is very great. The electrical waves at the surface of a conductor are thus, in some respects, very similar to the waves on the surface of water. The greatest motion in the latter case is at the surface, while it diminishes as we pass downward, and soon becomes inappreciable. Furthermore, the depth to which the disturbance penetrates into the water increases with increase of the length of the wave, being confined to very near the surface for very short waves. So the disturbance in the copper penetrates deeper as the waves and the time of oscillation are longer, and the disturbance is more nearly confined to the surface as the waves become shorter. Experiments show that the disturbance is almost entirely confined to the surface, for at a depth of only 7mm. the disturbance almost entirely vanishes. There are very many practical applications of these theoretical results for electric currents. The most obvious one is to the case of conductors for the alternating currents used in producing the electric light. We find that when these are larger than about half an inch diameter they should be replaced by a number of conductors less than half an inch diameter, or by strips about a quarter of an inch thick, and of any convenient width."

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ELECTROLYSIS OF NICKEL SALTS.

BY ALEXANDER WATT.

(Concluded from page 452.)

When pursuing the electrolysis of solutions of metallic salts, I have frequently observed that mixed solutions of salts formed with the mineral acids and those obtained with the vegetable acids have presented considerable advantages, so far as the character of the deposited metal is concerned. With a view to determine whether such combinations would prove equally advantageous in respect to nickel solutions, the two first experiments following were tried:

39. *Sulphate and Citrate of Nickel.*—To a solution of sulphate of nickel was added, a little at a time, one of citrate of nickel, the object being to ascertain whether the addition of the latter salt would cause the deposited metal to become softer, and therefore more susceptible of being burnished than is generally the case with the metal deposited from the simple sulphate solution. It has often occurred to me that a comparatively soft coating of nickel—one that could be readily burnished, instead of being polished in the usual way—might prove serviceable for some classes of nickel-plated work. In this experiment, the current from three small Daniells in series was used, and after each addition of the citrate salt a freshly-prepared brass plate, as the cathode, was immersed. It was noticed that even when only a small quantity of the citrate had been introduced, the deposited metal appeared somewhat whiter than that obtained from the sulphate alone, while, at the same time, the film retained its brightness, whereas the deposits from the sulphate invariably assume a dull appearance after a short immersion. On further additions of the citrate being given, the character of the deposit still further improved until about $\frac{1}{8}$th part of the citrate of nickel solution had been added, at which point the deposited metal became exceedingly bright and white, much more so, indeed, than is ordinarily the case with nickel deposits, which frequently have a yellowish tinge. On applying a steel burnisher to the various plates coated in the bath referred to, the deposited metal readily became brightened, without severe pressure of the tool; in fact, the metal felt somewhat soft under its influence, and a brilliant polish was obtained with comparative ease. As there are many surfaces in ornamental brasswork which are with difficulty "got at" by even the smallest polishing bobs, a solution that would yield a deposit soft enough to burnish should be useful, and I am disposed to believe that such a solution as I have indicated would answer the purpose aimed at.

40. *Sulphate and Acetate of Nickel.*—To a solution of sulphate of nickel was added, gradually as before, a solution of acetate of nickel, a fresh brass plate being immersed after each addition. The current from three Daniells was used, when a bright and very white film of nickel was promptly obtained, and when a fairly good coating had formed, the deposit was tried with a steel burnisher, which at once brightened the surface without excessive pressure. In this case, as also in the one just recorded, there was very little hydrogen given off at the cathode, but in the present instance there was a rather brisk evolution of gas at the anode. In both experiments the electrode surfaces were about equal, and in each case the deposit occurred on both surfaces of the cathode.

41. *Nickel and Ammonium Sulphates with Citrate of Ammonium.*—A solution of the double sulphates of nickel and ammonium being first prepared, to this was gradually added a concentrated solution of citrate of ammonia. In this experiment it was determined to see whether the solution of ammonia in an organic acid would tend to soften the deposit, and at the same time prevent the metal from assuming the usual dullness after a long immersion. The current from three cells was used, and with this a very bright deposit of a slightly yellow colour was quickly obtained; it was observed that the film retained its brightness for a considerable time, but afterwards turned dull. The deposit was, however, sufficiently soft to yield to the influence of the steel burnisher. There was a moderately brisk evolution of gas at the anode, but only a few bubbles of hydrogen appeared at the cathode, which seemed to remain stationary on the plate. The electrode surfaces were about equal, and the film formed on both sides of the cathode.

42. *Sulphate of Nickel and Tartrate of Ammonium.*—To a solution of sulphate of nickel was added, gradually, one of tartrate of ammonium, and a freshly-prepared plate immersed after each addition. The current from three cells was employed, and a very white and bright deposit of nickel was obtained when about one-ninth part of the tartrate solution had been introduced. The electrode surfaces were about equal. On trying the deposit with a steel burnisher, the metal appeared to be tolerably soft, but scarcely so much so as in some of the instances referred to.

43. *Nitrate of Nickel and Citrate of Ammonium.*—An attempt was made to ascertain if the addition of the ammonium salt would in any degree favour the deposition of nickel from its nitrate solution; but, as this was not the case, the solution, after several modifications and fruitless trials, was cast aside.

44. *Sulphates of Nickel and Sodium.*—To prepare a bath of this combination, a strong solution of sulphate of soda was added, a little at a time, to one of sulphate of nickel, and a clean brass cathode immersed after each addition. The addition of the sodium salt appeared to increase the resistance of the solution, as the deposition with the current of three cells took place rather slowly, and it was found necessary to increase the anode surface. Under these conditions, however, the films of nickel which were obtained were of fairly good colour, but not so white as those obtained from some of the foregoing solutions.

45. *Ferricyanide of Nickel in Ammonia.*—A quantity of ferricyanide of nickel was first prepared by precipitating a solution of sulphate of nickel with ferricyanide of potassium, the precipitate being afterwards well washed. Many attempts were made to obtain solutions of this salt; but it yielded most readily to the solvent action of strong liquid ammonia, with which an orange-coloured solution was soon obtained, which was afterwards moderately diluted with water. The solution, after being filtered, was electrolysed with the current from three cells, when a very prompt deposit of nickel was received upon a brass plate, the colour of which was fairly white.

46. *Benzoate of Nickel.*—A boiling solution of benzoic acid was first obtained, to which was gradually added moist carbonate of nickel, which soon became dissolved, forming a pale green solution. With the current from two cells no deposit of metal took place, so a third cell was connected in the series, when a freshly-prepared plate at once became coated with a bright film of nickel of good colour. After an hour's immersion the deposit was tried with the steel burnisher, when it soon became brightly polished with very moderate pressure of the tool, showing that the metal was tolerably soft for nickel.

47. *Salicylate of Nickel.*—A quantity of salicylic acid was first dissolved in water by boiling, and when all the acid was dissolved, moist carbonate of nickel was added gradually, each portion being allowed to dissolve before the next was added. The nickel carbonate readily dissolved in the hot acid liquor, with brisk evolution of carbonic acid, and a pale green solution was obtained. The solution, while still warm, was electrolysed with the current from three cells, when a white deposit of nickel was received upon a brass plate soon after immersion. In preparing the above solution, it seemed somewhat remarkable that so weak an acid should dissolve the carbonate of nickel so readily—a fact which had also been noticed in respect to lactic acid.

48. *Borate of Nickel.*—According to Brande* borate of nickel is "a pale green insoluble compound, formed by double decomposition." In my own experiments, however, I found that a solution of this salt could be prepared in the following way: A strong solution of boracic acid was first prepared by boiling crystals of the acid in water, and to this solution was gradually added moist hydrated oxide of

* "Manual of Chemistry." By William Thomas Brande, F.R.S., etc., p. 814, vol. i.

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nickel, which readily dissolved in the acid liquor, forming a pale green solution. When cold, the solution thus obtained was electrolysed with the current from three cells, when a white deposit of nickel slowly formed upon a brass plate, but chiefly on the surface facing the anode. It thus became evident that a soluble borate of nickel can be obtained by the direct action of boracic acid upon oxide of nickel. In many of these electrolytic experiments I have succeeded in obtaining solutions of metals of which I have seen no record elsewhere, and the present instance is one of them.

49. *Ferricyanide of Nickel in Cyanide of Potassium.*—To a strong solution of cyanide of potassium was added, in small portions at a time, moist ferricyanide of nickel, each portion being allowed to dissolve before the next was added. The solution thus obtained was afterwards electrolysed with the current from three cells, but no deposit of nickel could be obtained even when the cathode was briskly agitated in the bath. There was a brisk evolution of gas at both electrodes, and after a short immersion the anode became stained a deep black. A further addition of cyanide was then given, when the anode at once became clean, but there was still no metallic deposit upon the negative plate.

50. *Potassio-Tartrate of Nickel, with Soda added.*—Wernicke* states that from a "solution of the hydrated oxide of nickel, in a mixture of cream of tartar, and a little soda and water, electrolysed by means of a current from two Daniell cells," he obtained a "layer of solid hydrated peroxide of nickel upon the anode." To modify this experiment, a strong and hot solution of bitartrate of potassa was first formed, to which was afterwards added a small quantity of a solution of carbonate of soda. With the current from three cells, a patchy and streaky deposit of nickel of very dark colour was obtained upon a brass plate, but the anode remained perfectly clean.

Deposition of Nickel by simple Immersion.—It has generally been understood that nickel, with one or two exceptions, does not deposit from its solutions upon other metals by the process of simple immersion. Having noticed, however, in the course of these experiments that this metal will deposit—upon zinc more especially—from a greater number of solutions than has hitherto been accepted as probable, I determined to pursue a series of trials in this direction, the results of which are given in the following table A. I may say, however, that from neither of the solutions named would nickel deposit upon copper by simple immersion; while, on the other hand, strips of magnesium readily received a coating of the metal in many of them.

TABLE A.

Nickel Solution.	On Zinc.	On Aluminium.	On Magnesium.
Sulphate	Yellow film of metal with evolution of hydrogen	...	Dark metallic stain.
Sulphate with common salt	Brownish film with H.	...	Same.
Sulphate of nickel and sodium	Yellowish film	...	Same.
Sulphate of nickel and magnesium	Black stain with H	...	...
Ammonio-chloride	Yellow film of metal	Slight film	...
Nickel carbonate in cream of tartar	Slight metallic film	...	...
Ammonio-nitrate	...	Slight film ...	...
Ammonio-sulphate	Yellow film with H	...	...
Chlorides of nickel and sodium	Yellow film with H	...	...
Potassio-tartrate	Same	...	...
Nitrates of nickel and ammonium	Dark stain	...	...
Nickel acetate and ammonia	Brown metallic deposit	...	Metallic stain.
Ammonio-acetate	Prompt yellow film	Same, but slower	...
Oxide in ammonia	Film formed very quickly	...	...
Citrate	Same	...	A stain.
Tartrate	Yellow film	...	Metallic stain.
Carbonate in cyanide	Same very quickly formed	...	...
Lactate	Metallic stain	...	Metallic film.
Acetates of nickel and sodium	Yellow film	..	Metallic film.
Carbonate in sal-ammoniac	Metallic but iridescent film	...	Metallic stain.
Sulphate with potash sulphate	Slight film	...	...
Carbonate in alumina sulphate	Yellow film with H.	...	Ammonia given off freely in gaseous bubbles.
Acetates of nickel and potassium	Yellow film	...	Metallic film.
Cyanide of nickel and potassium	...	Slight film ...	Metallic film.
Sulpho-cyanide	Slight film	Same.	...
Ammonio-citrate	Dark film	Slight.	...
Carbonate in sulphate of ammonia	Iridescent film	...	...
Sulphate with tartrate of ammonia	Yellow film formed promptly	...	...

Respecting the character of the deposits obtained by simple immersion, it was noticed that the nickel obtained upon the various strips of metal, even when in its most perfect metallic condition, was always of a yellow or brownish-yellow colour, and never in a single instance white, or even approximately so. The same peculiarity in the colour of nickel deposits is generally observed when weak currents are used to deposit the metal. Indeed I had noticed this many years ago, before the introduction of the dynamo-electric machine, when the voltaic batteries employed had been long in use, and the dilute sulphuric acid had become saturated with zinc. Under these conditions the deposited nickel had always a disagreeable yellow tinge, and this was only rectified when at my suggestion the batteries were renewed more frequently than had been the custom at the establishment referred to. At this period much of the nickel-plating executed in London and elsewhere had a decided yellow tint, and this became more apparent when compared with nickel-plated goods from the United States and France, which, although not so stoutly coated as was the custom in this country, were remarkable for the extreme whiteness of the nickel upon them. Respecting the differences in the colour of electro-deposited nickel, there is no doubt whatever that a low current produces an indifferent colour in the deposited metal. Besides this, the nature of the electrolyte has also a powerful influence in this direction, as I have endeavoured to show in some of the results obtained, by adding to nickel solutions other liquids which not only influenced the colour of the deposit by rendering it whiter, but also appeared to have a decided effect upon the hardness of the metal. It is quite possible that other modifications besides those suggested may be found advantageous, but it is hoped that amongst those given may be found several that will deserve further trial.

* *Journal* of the Chemical Society, vol. ix., p. 307.

CENTRAL STATION ELECTRIC LIGHTING ON THE CONTINENT.

BY KILLINGWORTH HEDGES, M.I.C.E.

(Author of "Central Station Electric Lighting.")

NO. I.

The progress of electric lighting in France has not, until the last two years, been more rapid than in England, although there has been no Electric Lighting Act with the so-called vexatious clauses to block the way. As in our own country, however, there has been no retrograde movement; where the new illuminant has been established it still remains. The moribund Jablochkoff candle with its variegated flicker has been superseded by the incandescent lamp for interior lighting, and for street work the arc lamps of Gramme, Jasper, and Brush are fairly satisfactory. The principal streets of Marseilles are most effectively lighted by the first system. Brush lamps are employed at Hyères, the installation being worthy of notice in that the electric light is worked by the local

gas company, who find that the cost of maintenance is much less than gas-lamps of similar power. Underground cables are used for both these installations, which are, however, only subsidiary to gas, and it was with some surprise that on visiting the town of St. Tropez, which is some 25 miles from the nearest railway station, one found that the electric light had been successfully used in the streets and in some of the houses for the past eighteen months.

An alternating-current Gramme dynamo is driven by a horizontal condensing engine of 50 h.p., constructed by Berger Andre, of Thann, Alsace. The E.M.F. of the primary is 2,000 volts, and is converted by transformers into 100 volts; there are two lighting circuits, one for the 100 street lamps, and the other for private customers. The primary leads, which are principally of silicium-bronze wire 5mm. diameter, are carried on brackets from the sides of the houses much in the same way as the Government telegraph wires are usually run. The transformers, which are of the Zipernowski type, but manufactured by the Edison Company, Paris, are slung high up from insulated brackets, also fixed to the walls. The transformers are well out of the way, and are protected from the wet by loosely-fitting bell-shaped covers. The secondary wires are led in a similar manner, but under the primary, the 100-volt 16 c.p. lamps being fixed in the existing street lanterns. No inconvenience has been experienced with this overhead system, which at first appears to be somewhat dangerous, especially as naked wires are used throughout the city for all the overhead circuits. The charge made for each 16 c.p. lamp per annum is high, the Municipality paying £3. 3s. and private consumers £3. 8s., which includes the enewal of lamps. In spite of the cost being considerably above the petroleum-lamps, which were formerly used, the electric light is preferred, and a very large number of the inhabitants have asked for a general supply to be afforded to all private houses. The transformer system will, before long, be very largely adopted for the electric lighting of the many small towns which are at present quite inefficiently illuminated by oil-lamps placed in lanterns of a most antiquated type. Many of these towns are within a few miles of one another, so that it is possible to illuminate them all in a group from one central station. This plan has been adopted with success for lighting the towns of Dieulefit, department Drôme, and Valreas, Vaucluse, the distance apart being 18 kilometres; the high-tension primary current from the one central station is carried by ordinary telegraph poles, and is reduced to a working potential of 100 volts by Zipernowski transformers, which are arranged in a similar manner to those at St. Tropez.

The electric light has been recently installed at the casino of Monte Carlo, which in all probability is the only establishment in the world possessing three distinct systems of illumination—namely, oil, gas, and electricity. Oil-lamps were introduced a few years ago after the attempt to blow up the gas main by dynamite with the object of making a raid on the tables. The attempt partially succeeded, as the gas lamps were extinguished by the explosion. To guard against its recurrence each electrolier has oil-lamps as well as the incandescent lamps. Two of 16 c.p. are placed in globes similar to those used for the oil, and it is not easy to identify the method of illumination. In all, there are 1,100 electric lights; 500 are employed on the stage of the theatre, and 328 in the magnificent chandelier which lights the concert hall.

The installation is worked by the staff of the gas works which belong to the Casino. As there was no room for the electrical plant, a site has been acquired, about 500 yards from the rooms, by cutting away the sea cliff, the electric cables being run underground in wooden troughs, which are filled with sand.

Two compound condensing steam-engines of the inverted marine type, constructed by Schneider, of Creusot, supply the power. The steam pressure is 90lb. The three boilers are of the multitubular Cornish pattern, and of these one is kept in reserve. A constant E.M.F. of 110 volts is maintained by the Blathy regulator, which consists of a number of wires of varying lengths, which are raised or lowered out of a mercury cup by means of a balanced solenoid, which is operated by a special return wire connected to the most distant part of the main leads. The resistances are automatically inserted or cut out according to the variation of the E.M.F. In fact, the success of this apparatus is due to its sensibility, which may be said to anticipate the turning out or increasing the number of lamps, and thus controls the output of the dynamo. The current for the magnetisation of the exciting dynamo, of course, passes through the resistances. Returning from our visit to the south, *viâ* Italy, one noticed that great progress in street lighting had taken place at Turin in the past year. About 600 arc lamps are used, and the number is to be increased. They are slung on wires stretched across the streets about the height of the windows on the first floor, the conductors are led on insulators on the sides of the houses, except where the squares have to be lighted, when insulated conductors, in wooden troughs, are carried to the base of each standard. To trim the lamps, all of which appeared to be of the Thomson-Houston pattern, a portable balanced ladder is employed, which resembles a short fire-escape, in that it can be elongated at will. Spare lamps and carbons are carried on the truck which forms the base of the ladder, and the apparatus is also used for fixing the insulators in the walls and running the wires. There seems to be no special objection to this plan of fixed lamps, as the trimming is carried out in the early morning. Any inconvenience is fully compensated by the quality of the illumination, which is far superior to that from lamps placed at intervals at the sides of the streets.

Arc lighting is also used for interior work and is far superior to what we have been accustomed to here—it would be difficult to find a better lighted restaurant than that at the Turin railway station. The method was first adopted on account of the cost, which is less than gas, and has not been changed, although there would be no difficulty in obtaining a supply from the Edison central station, which is rapidly extending its system of mains. The Cruto incandescent lamp is manufactured near Turin, and one naturally expected to find it largely adopted, but it was not until the station of Culoz, in France, was reached that any quantity were seen, which appears to bear out the old adage that "a prophet is not honoured in his own country." A great display of electric lighting is to be undertaken by the Municipality of Paris, and the streets were up in all directions for the purpose of running wires, and also making improvements in the roadway and pavements. The promise that, with the opening of the Exhibition, the streets are to resume their gala appearance is now fulfilled, and the flickering "Phare gas-lamps" are relegated to obscurity, where it is hoped they will for ever remain.

ELECTRIC LIGHTING OF LONDON.

Mr. Gisbert Kapp has written the following letter to the *Times* in reply to that of Prof. S. P. Thompson, reprinted in our last issue:

"Electrical engineers will have read with the greatest astonishment the long letter which Prof. Silvanus P. Thompson contributed to your columns on June 1. Major Marindin's report has been received with approval by nearly all who are able to take an unbiased view of the matter, and the verdict both of professional men and of the scientific Press was entirely favourable to his conclusions. Broadly speaking, therefore, the electrical industries are satisfied with the result of the enquiry, and all they now desire is to get to work as soon as possible. There is, however, one company which is very dissatisfied with Major Marindin's report, and its cause is now championed by Prof. Thompson, who would have your readers believe that the system of supply which would have been adopted by this company (the Electric Power Storage Company) is the only absolutely safe one, whilst the system of its two successful rivals, the London and Metropolitan Companies, are insecure because a whole district served by them might be suddenly plunged into darkness through the 'mere derangement of an engine or boiler.' This sounds very alarming, but the experience of the last six or seven years in American and European electric

light stations has shown that, although the continuity of the light depends upon moving machinery, there has hardly ever been a case where a district was plunged into darkness. In some stations the current has not been off the mains for even a minute during a period of several years, and we may therefore conclude that the risk of interruption of current is really infinitesimal. Those who talk so glibly about the advantage of storage over direct supply seem to take it for granted that boilers, engines, and dynamos must sooner or later break down, but that storage cells will never break down. This is absurd, and I think even Prof. Thompson will admit that a 'mere derangement' in a storage battery (say, the breaking of a glass cell and escape of the acid) or a derangement in the intricate and delicate control mechanism required in connection with such batteries will plunge a district into darkness. Thus far there is little difference between the two systems, for either can be made practically safe, but there is a great deal of difference as regards their commercial aspects. Roughly speaking, we may take it that the equipment of a central station on the plan advocated by the Power Storage Company will cost twice, or perhaps three times, as much as an equally efficient station on the alternate-current and transformer system, and, as depreciation and interest on capital expenditure have to be paid out of the earnings, in either case it is clear that the storage system will have a hard struggle to compete on equal terms against the transformer system. The advocates of the former, although they admit the greater capital expenditure, are always asserting that the working expenses will be so much less. This may or may not be the case, but up to the present the point has not been practically demonstrated, and the great alarm shown by the storage companies on account of the incursions of the transformer companies into their own special districts tends to show that they are, after all, not so very confident as to their ability to work the system cheaply.

"It is amusing to note the complete change of front in the argument as regards monopolies which underlies Prof. Thompson's letter. During the enquiry the storage companies laid great stress on the fact that 'districting' would not confer upon any company an exclusive monopoly, because there was always the possibility of a revocation of the order if they did not do their work well, and the potential competition of another company who might be able and willing to do the work better. No, they did not ask for a monopoly; they simply wanted a fair opportunity of doing good work. Well, with the exception of the one company already mentioned, all the other storage companies have obtained what they wanted. Yet they are not satisfied, and Prof. Thompson now says that if the Board of Trade were to adopt the recommendations of Major Marindin it would hand over 'nine-tenths of the allotted districts to the exclusive control of either the Metropolitan Electric Company or of the London Electric Supply Corporation.' Now this is a very misleading statement. If the storage companies only ask for one-tenth of the area (taking care to pick out the most promising districts), and get it, is that any reason why the other nine-tenths should be refused to their competitors? Clearly not. The alternate-current companies are ready to serve the remunerative as well as the less remunerative districts, and by their system they are able to do this on a sound commercial basis. They have no monopoly, and do not object to storage companies coming into their districts, knowing perfectly well that they will easily be able to hold their own. A great deal has been said as to the inability of the alternate-current companies to supply motive power. I do not admit this inability, and Prof. Thompson himself must know that mechanical energy can be obtained from an alternating current, for he has seen it done as well as I; but the importance of the power business has been greatly over-estimated. Let anyone make a house-to-house canvas in the West End to find out how much light and how much power the several householders would take, and he will see that light is the commodity immediately in request, whilst very few will care to take power. In other parts of the town the proportion may be reversed, but that is no reason why we should not give to the private householder that what he most wants—namely, light."

CORRESPONDENCE.

LIGHTNING CONDUCTORS.

To the Editor of The Electrical Engineer.

Sir,—I scarcely feel certain as to whether you feel any interest in the question of lightning-conductors, so far as they regard the safety of your own personal friends.

I know, of course, that you take a deep interest in the *science* of this moderately important question. But it has become to me and my friends a very important question, and I ask, most humbly, your advice how you consider I should proceed to obtain safety under the following circumstances:

I have taken an unfurnished room at 59, Dalston-lane. It is a charming old house, with strong built walls and splendid doors, with at least six bolts to every door. So far so good. But our next door neighbour on the "port hand," looking towards the road, is St. Bartholomew's Church.

Now, St. Bartholomew's Church is (I wish you to understand) so absolutely next door that the windows look out into my landlord's garden. We can hear every note of the organ, and nearly all the choir, except when they sing *pianissimo*. I only mention this to describe to you how close I am situated to St. Bartholomew's.

Perhaps you may recollect that we have had some thunderstorms lately. They were not very near here, as the least I could count, between flash and crash, was five (counting fairly and truly to the best of my ability), and so I believe, making the storm five miles away.

But the next thunderstorm may come nearer (and they seem "fooling around") and then, if you will only listen to me one second, I will tell you my troubles. They are as follows:

Our house is only two storeys high, probably twenty-five feet. Now, I estimate the church as sixty or seventy feet high. It is a long barn-like building, about one hundred and twenty feet long, with a steep slope to its roof, and a stone cross at each gable end. I have looked in vain for any sign of a lightning-conductor, and cannot see one. It is possible that it is concealed *inside* the church. But the house I live in is evidently many years older than the church, and the church has been added on to the house; the church, as far as atmospheric electrical effects are concerned, rules the safety of this house.

I have, at the risk of wearying your readers, given you a brief summary of the condition of St. Bartholomew's Church, Dalston, and 59, Dalston-lane, and I humbly ask you, Mr. Editor, whether you can kindly give me advice on the following queries which have arisen in my head, night and day (particularly when the last thunderstorm was on), as to regards how it is possible to make anybody responsible for the safety of this house and its inmates in time for the next "electrical atmospheric disturbance" (I believe that is the proper term):

Firstly.—Ought there not to be a proper system of lightning-conductors to the church, with no sham earth connections?

Secondly.—Supposing that there ought to be such system, of which I think you will have little doubt, who is responsible for the cost, or to insist that the work shall be executed?

Thirdly.—Can any person, or body of persons, corporate or not, erect with impunity and with no responsibility, a building next to another (previously constructed) which new building becomes, when unsupplied with proper lightning-conductors, a danger to the older building?

These three questions may be of importance to more persons than merely to myself and friends, and I therefore ask you in the interest of the public to print this letter in your valuable journal in order to ventilate the question.

If you can kindly find room therefore for my letter, and give me also some advice on the subject, I shall be very greatly obliged.—Yours, etc.,

F. C. Webb, M.I.C.E.

59, Dalston-lane, N.E., June 11, 1889.

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THE

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IMPORTANT NOTICE.

Although the Paris Exhibition is open, the major portion of the exhibits are in so backward a state that any systematic description is almost impossible at present, so we shall wait a short time till the chaos of packing cases becomes a neat arrangement of exhibits. It is needless to tell our readers that—so far as our description of the electrical exhibits is concerned—our attention will, in the first place, be directed to the interests of English and American exhibitors. A special edition of this paper, with the report of the exhibition in two languages—English and French—will be obtainable in the Exhibition.

ELECTRICITY IN AID OF STEAM POWER.

If Ireland is to enter upon a more active history of the kind that has marked the progress of Great Britain, there is no doubt that it must be much on the same lines, or must be due to similar causes, namely, activity in manufactures of different kinds. In England and in Scotland manufactures owe much to cheap power. In many parts of Ireland steam power may not be so cheaply obtainable, but by the aid of electricity the power which Nature has placed in her possession may be in many places made subservient to the requirements of manufactures which might be carried on at a profit in the Green Isle.

So much is now being proposed as means of encouraging trade and agriculture in that country through the medium of railway and other transport facilities, and by drainage works, that it might possibly be said that further proposals are at present quite unnecessary. If, however, feeder railways are to be made, it may be urged that something more than agricultural development may be served by them. Manufactures of several kinds which we need not specify might be encouraged, and cheap power in suitable localities would become one of the first aids to development in that direction. As is well known, there are in numerous parts of Ireland some splendid sources of water power. They are, however, most of them situated at distances from the centres of population, or from the existing ports or railways. Electricity should, to a great extent, remove this difficulty, and the construction of light railways should do a great deal more.

It has been calculated,* on satisfactory data, that there is at least a million horse-power, more or less, available in different parts of Ireland, taking the whole year round, the availability depending not on the quantity of water running to the sea, but upon suitability of the sites at which the power could be realised for manufacturing purposes. This qualification puts an enormous proportion of the whole available supply beyond the reach of commercial application, so long as it is essential that the manufactory or mill must be placed, as in the old days of water-power application, on the site of the waterfall. This, however, is no longer a prime necessity. With the cheap means of power transmission which the modern generator and motor, and we may also say the modern turbine, have placed in our possession, many of the sources of power hitherto unavailable may be brought into requisition.

Within a radius of ten or fifteen miles of some of the largest waterfalls there are many suitable sites for the establishment of mills or manufactories, and by means of high tension currents the power derivable from these water supplies might be transmitted, not simply to one or two very large establish-

* Kane's "Industrial Resources of Ireland.

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ments, but to numerous small mills, and in this way the minor capitalist manufacturer would have the means which the cost of steam power at present places beyond his reach. Even if an extravagant reduction be made in the water power theoretically available, there is vastly more practically at hand than could by any means be employed in Ireland for a great many years, in most eligible positions. At Bandon, Cork, Killarney, Clonmel, Waterford, Wexford, and Limerick in the south, amongst others, there is not less than 40,000 h.p. obtainable in places from which the power could be electrically transmitted to large and small consumers. On the Shannon, within twelve miles of Limerick, there is a fall of 97ft., and a sudden fall within a short length of that big river of upwards of 21ft. Here with practicable works not less than 14,000 h.p. could be obtained. Proceeding northward, it will be found that Lough Corrib and Lough Mask discharge into the sea at Galway with a fall of 13ft., affording an easily available 1,300 h.p. Where Lough Mask discharges into Lough Corrib a fall of 36ft. exists, and at least as much power as that last mentioned is to be had. This is about twenty-one miles from Galway, and lake navigation is available. Further north there is at least 1,800 h.p. running to waste at Ballyshannon, and this is within twenty miles of Sligo port. At Belleek is again a large supply, and at numerous places further north, including Lough Neagh and Coleraine. It is quite unnecessary to give a list of the large number of places at which from one to several hundred horse-power could be utilised. It is not, however, applicable where it is, and we purpose only in this article to direct attention to the possibility of making it useful by means of electric transmission, for not only ought it to be made available in this way for manufacturing purposes, but also for the many purposes to which even in existing towns in Ireland power distribution to large and small consumers might be made a source of industrial development.

THE LIMIT OF SPEAKING ON TELEPHONE LINES.

BY DR. V. WIETLISBACH, OF BERN.

The most important electrical properties of a line are its resistance, capacity, induction, and insulation. A perfectly accurate theory would also have to take into account the polarisation of the dielectric employed for insulation and the magnetisation of the material of which the lines consist. And, further, we have to take into consideration the fact that the very rapidly undulating telephonic currents do not uniformly utilise the whole cross-section of the wire, but chiefly circulate on its surface. Sir W. Thomson has calculated that a current of 150 waves per second only penetrates to a depth of 3mm. into the wire, so that the largest useful cross-section would amount to 6mm. If we wish to make use of larger cross-sections, we must give to the conductors the form of hollow tubes or flat ribbons, in order to avoid waste of conducting material. Telephonic currents generally are even more rapid, and the useful cross-section is therefore reduced to 4·5mm. For this reason so-called compound wires have lately been used for long lines, consisting of a copper tube with an iron or steel core.

In addition to these requirements, which can be clearly defined from a technical point of view, numerous other questions have to be considered in telephony, such as the nature and sensitiveness of the apparatus, the greater or less aptitude of the voice and the ear of the persons conversing, so that it is quite impossible to determine in a general and accurate manner the distance to which speaking is possible. In spite of this, we find articles published continually which treat of this subject. From a theoretical point of view, one can speak to any distance. One has only to bring apparatus and lines in agreement with one another and with the desired distance. Similar conditions prevail here as with the telegraph. If a Morse apparatus has to be worked at a short distance, one single element is sufficient. For longer distances, up to about 100km., an iron wire of three millimetres and a battery of 50 elements are employed. On long direct lines—for instance, Berlin, Rome, Vienna, Constantinople—a wire of 5·6mm. and several hundred elements or a powerful dynamo are used. On long submarine cables these strong currents must not be employed, because they would quickly destroy the insulation. In this case we are restricted to the use of extremely sensitive apparatus, which can be worked securely even with minimum currents. Thus the telegraph adapts itself, by convenient arrangements of line, apparatus, and current, to any distance whatever. The longer the distance the more complicated the arrangements, and the more costly the installations; but this is the only reason which forbids the employment of very long lines. On the other hand, an installation which is calculated for a line of 100km. is not fitted to work on a line of 1,000km.

In like manner we can by improving the line, and by strengthening the transmitter and the sensitiveness of the receiver, telephone to any distance. The most essential point in this case, too, is the convenient arrangement of the different accessories, which, it cannot be denied, is a more difficult matter than in the case of the telegraph, for the simple reason that a good telephonic transmission requires much greater care in the construction of the line. That the clearness of transmission depends much more on the proper arrangement of the various accessories is proved in the most characteristic manner by the evidence of a New York subscriber, who complains that he has the greatest difficulty possible in understanding another New York subscriber, while he can converse with a Boston subscriber (a distance of 250 miles) as easily as if he were in the same room.

Mr. Preece has had the unfortunate idea to apply a formula which Sir W. Thomson has given for cable telegraphy to telephone lines, and the formula possessing such weighty credentials has found numerous successors. The formula in question is

$$t = \frac{130,000,000}{l^2 \mathrm{K R}},$$

where t expresses how many times per minute the word "Paris" can be telegraphed through the cables, l length of the cable, K capacity, and R resistance per km. The correctness of the formula for the purposes and the circumstances under which it was deduced cannot be doubted, but the manner in which it is proposed to use it for telephone lines is an entirely erroneous one. We have at the outset spoken of four electric properties which characterise a line; Thomson's formula only contains two—capacity and resistance. This is easily explained by the fact that Thomson in deducing the formula has telegraph cables exclusively in his view These are generally insulated with guttapercha; their insulation is therefore always the same, and, what is more, relatively very high. The line always consists of copper strands, and the induction is consequently very small. Even under these simple conditions the formula is not absolutely correct, but it suffices for the purpose it has to serve—namely, to calculate in cables of uniform make the most favourable cross-section at a definite speed of transmission.

In cable telegraphy the cable is charged at one end, and then again discharged. By the combination of individual

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charges and discharges of different length and unequally rapid succession, the cablegram is obtained. In consequence of the great length and the large capacity of the cable the manipulations of the transmitter are not instantaneously transmitted to the other end of the cable, but a certain time elapses between the sending and the receipt of the signals. If now the transmitter is manipulated too quickly, the charging and discharging currents are mixed at the terminal station, and the receiver executes movements which in no way correspond to those of the sending key; so, for instance, a long depression of the key can be changed into a short interval by the discharge current of the previous signal, or a short interval between two depressions of the key into a long one. Thomson's formula determines the rate of speed at which the key ought to be manipulated in order to receive at a given charging capacity of the cable correct signals at the receiving end. Thomson's formula, therefore, refers to G. P. cables, immersed in the sea, traversed by charge and discharge currents, and operated with a syphon recorder, or some such sensitive receiver. And now it is proposed to apply this formula to lines through which currents are circulating, which have not the least resemblance with those employed in cable telegraphy, to apply it for the determination of something about which nobody has any clear conception. That this vagueness is not on the side of those who disapprove of the misapplication of the formula is shown by the statements of those authors who have made use of this formula, and which are contained in the following table:

If we write Thomson's formula in the form

$$A = l^2 K R,$$

A has the following maximum values, l being expressed in km., K in microfarads, and R in ohms.

	Preece.	Jacques.	Madsen.	Wietlisbach.	Line, Chicago-New York.
Copper overhead	15,000	2,000-4,500	3,000	—	Over 50,000
Cable	12,000	2,000-4,500	3,000	1,000	Less than 5,000
Iron overhead ...	10,000	2,000-4,500	6,000	—	—

I leave it to the reader to draw his own conclusions from this table.

The product, capacity, into resistance, which is determined by Thomson's formula is certainly a measure of the efficiency of telephone cables. The smaller this product the better the cable for telephonic purposes, and for single-wire cables of uniform make the distance of speaking may be approximately determined. But this determination becomes impossible as soon as cables of different make, whose insulating materials are differently affected by polarisation, are to be compared with one another, or as soon as the cable no longer forms the sole constituent of the line.

If we consult experience we find that telephoning is possible.

On overhead copper wire to a distance 2,000km.
On iron wire „ „ 300km.
On single-wire cables „ „ 10km.
On double-wire cables not determined.

The latter distance entirely depends on the construction of the cable, and may certainly exceed 100km.

If on most of the lines these long distances are not reached, the fault rarely lies in the fact that the product of capacity and resistance is too large, but, provided that faulty apparatus are not responsible for it, the insulation of the line is often insufficient, or the insulating material, especially in cables, is not properly chosen, or the magnetic inertia is too large.

From these considerations we may draw the following conclusions:

1. There does not exist at present any formula or rule from which the limit of speaking distance can be calculated even with approximate accuracy.

2. The attempts made hitherto are not decisive, because they rest on a false basis, or made with a faulty apparatus, so that it was not the line but the apparatus which gave out.

3. On overhead copper lines the distance has not been reached yet at which telephoning is impossible.—*New York Electrical Review.*

SOME RESULTS WITH SECONDARY BATTERIES IN TRAIN LIGHTING.*

BY ALEXANDER S. BROWN.

It is now four years since the Pennsylvania Railroad, appreciating the advantages of electric lighting for train lighting, began a series of experiments with the secondary battery, for the illumination of parlour cars.

I am unable to give the cost of lighting by any of the batteries referred to, as the expense appears to have been a secondary consideration compared with the necessity of securing the best system of illumination.

The first experiments made by the company were with the Faure accumulator, which was brought to this country from France in the spring or early summer of 1882, and put on passenger coach No. 397 in August of that year. The car was run for a few days only, but enough was learned in that time to show that the lighting of cars by secondary batteries was perfectly practicable, when a modified form of the battery could be obtained.

During the summer of 1884 experiments with the Brush storage batteries were commenced at the Altoona shops of the Pennsylvania Railroad, and continued through the fall and winter of that year. These experiments were made by Dr. Dudley, and proved so successful that eight parlour cars, which were being constructed at that time, were equipped for incandescent lighting and put into regular service on April 1, 1885.

The Brush cells used consisted of three plates each, two negative and one positive, the amount of surface of the positive plate being equal to that of both the negatives. These plates differed from those now used, there being no paste in their composition. The negative plate was designed to give the greatest possible amount of surface from the least weight of material. The positive plate measured 8in. by 9in. by 1in. and the negative 8in. by 9in. by ½in.

These batteries are rated at 70 ampere hours, but the hard usage they received soon reduced their capacity, and at the end of a year's time the positive plates were almost entirely destroyed. In fact, I have taken plates out of the cells which had holes in them fully 4in. in diameter, while the deposit in the bottom of the cell would be from 1in. to 1½in. in depth. The plates also had a decided tendency both to buckle and grow, and in a number of cases it was a very difficult matter to remove the plates without injury to the cell. I allude more particularly to the positive plate. The weak points in the Brush battery were the small number of ampere hours per pound of material—about two, I believe. There was a tendency to buckle and sulphate, and the arrangement for connecting the plates was such that there was oxidation at the junction, causing the plates to break when subject to the motion of the car. While using the Brush battery the cars were wired with the battery-boxes, one on each side of the car, coupled together in series, each box holding three trays, and each tray containing four cells, this giving a total of 24 cells to a car, or an E.M.F. of 48 volts. The lamps used originally were of the Brush-Swan type.

After using this style for some time an improved pattern of Brush-Swan lamp was substituted, but the great drawback to this lamp was its frailty, the breakage per day often averaging four per cent. of the total number of lamps in use on all the cars. These lamps required about 45 volts and 1 ampere of current, and each car contained ten lamps, seven in the body, one in the smoking-room and one in each vestibule, thus using about 10 amperes of current, and as the batteries were rated at 70 ampere hours, we should have obtained from six and one-half to seven hours good light, but it was very seldom, after the batteries had been used for a short time, that we could get

* A paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.

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over five and one-half hours. This could hardly be called economical, for to obtain five or six hours' light we were obliged to charge from 15 to 20 hours with a Brush arc light dynamo giving a current of about 10 amperes. Then taking the weight into consideration, each time the car needed charging, the trays, six in number, and weighing 1,200 pounds, had to be loaded on the truck, pulled over to one side of the car, and the discharged trays taken out and freshly charged ones put in their place. The remaining three were then taken around to the other side of the car and changed in the same manner, which was difficult. During the month of December, 1886, we commenced using one battery of the 7 B type, manufactured by the Electrical Accumulator Company. This battery was a decided improvement over those previously used, giving as it did nearly double the number of ampere hours for the same weight of material. After using the battery for about a year the positive plate began to give way and new ones were substituted, the negatives, however, being retained, they not having deteriorated. In fact, we are still using the negative plates of our original 7 B battery. This battery proved to be so satisfactory that in June, 1887, we added two more of the same type, and two manufactured by the Julien Electric Company. The latter batteries were similar in size and shape to the 7 B type of the Accumulator Company, but did not seem to stand the hard usage so well, as they would crack instead of buckling, and allow a large quantity of the paste to become loosened and fall out. It is proper to state, however, that these plates were made especially for us to fit the cells we were using, and were not of the regular Julien type. After the positive plates of this battery became worthless, and not having any others to put in their place, we decided to make a kind of consolidated affair, and see how Julien negative and Accumulator positive plates would work together. The result was extremely satisfactory, and we have had no trouble with them whatever, excepting the occasional buckling of a positive plate.

During the fall of 1887, we began substituting the Accumulator batteries for the Brush batteries, and by the end of the year we were using them altogether, with the exception of the two Julien I have mentioned. We, however, kept 96 of our best Brush cells, to be used in case of an accident to the incandescent dynamos, which are used to supply the current for the railroad telegraph as well as for lighting the passenger station.

After the change in batteries had been made, it was thought best to change the system of wiring the cars, so that instead of its being necessary to put batteries on each side of the car, we need only put them on one side, and get the same amount of light. This was done by connecting the two boxes under the car in parallel, and substituting 23-volt Edison lamps for our 45-volt Brush-Swan lamps. After doing this we found that we were able to get as many hours' light from 12 cells as we formerly did from 24. Of course this change reduced the expense of lighting the cars considerably, for where we formerly had a change of battery for each car, or 48 cells, we now needed only 24 cells per car, with a few extra ones to be used in case the 12 cells would not be able to supply sufficient light for a long trip. This system of lighting proved so successful that it was decided to substitute it for gas in the remaining seven parlour cars. The wiring of these cars was commenced at the Meadow shops, near Jersey City, last September, and has just been completed. These cars are arranged for the 23 C type of the Accumulator Company's battery, and 19 B type of the Julien battery. The battery-boxes under the cars are larger than the old style, and contain four trays or 16 cells, the lamps we used taking 23 volts E.M.F. Changes were also made the first of the year in the system of charging, and the batteries are now charged from an incandescent dynamo instead of an arc, thus enabling the batteries to be charged with any amount of current desired.

In 1887, the Pullman Palace Car Company commenced using the electric light on one of three trains of the New York and Chicago limited express, and the charging of the batteries at Jersey City was given into the hands of the Pennsylvania Railroad Company. The batteries used were the 7 B type of the Electrical Accumulator Company, 30 cells to a car, and usually there are six cars in the train. These batteries would furnish enough light for one trip, and each time the train arrived at either terminus it was necessary to replace them with freshly charged cells. This was not objectionable at Chicago, for the train arrived there in the morning, so that they could be charged during the day, but in Jersey City, where the train did not arrive until evening, the work was very difficult on account of the dynamo being in use for other purposes. After this one train had been running a short time, another one was fitted up, 19 B type of Julien battery being used. After Mr. Bauer became connected with the Pullman Company, he did away with charging the batteries at the ends of the line, and introduced a Brotherhood engine and Eickemeyer dynamo in the baggage car of each train, in order that the batteries might be charged in transit. When the train leaves Jersey City, the baggage car is on the rear, and consequently no charging is done until it leaves Philadelphia, where the train is reversed, bringing the baggage car next to the locomotive. The batteries are charged continuously until the train reaches Chicago, and the same practice is continued on the return trip. The steam for driving the Brotherhood engine is taken from the locomotive boiler, and the exhaust is used for heating the train.

So far as the Pennsylvania Railroad is concerned, the electric lighting of passenger trains may be considered an assured success, and leading as it does to the abolition of kerosene-lamps, and incidentally encouraging the adoption of steam heating, the safety and comfort of the passenger is certainly increased.

THE MEASUREMENT OF THE CANDLE-POWER OF ELECTRIC STREET LIGHTS.

BY PROFESSOR STODDARD.

In measuring the candle-power of electric street lights while burning in their position on the street, one has certain difficulties to contend with which are absent in ordinary photometric measurements. The chief of these difficulties lies in the facts that the lamp to be tested is at a considerable height above the horizontal plane which the photometer can, in most cases, conveniently occupy, and that the work must be done out of doors. In compliance with the request of the editor of the *Journal*, I will briefly describe the way in which I have sought to solve the problem which presents itself.

In the first place, the photometer must be modified, so that the light coming from a point considerably above its plane shall yield a beam parallel to the bar. This may be done in two ways :

First.—By having the photometer bar horizontal, as usual, and placing at one end of it a reflector, which shall throw the beam from the electric light along the bar. This reflector must, of course, be a plane surface, and may be an ordinary mirror or a totally reflecting prism.

Second.—By inclining the bar in the vertical plane so that it shall point directly at the lamp. Of these two methods I prefer the latter, because the use of a reflector of any sort involves loss of some light, the amount of which must be carefully determined and introduced as a correction in the final calculation, while it offers no advantage over the direct method to compensate for the greater trouble and liability of error in the results.

In the second place, a direct measurement of the distance from the arc to the Bunsen screen is, in general, not easy, and the modified photometer should provide some way for its indirect and, at the same time, accurate determination.

Thirdly, the photometric work must be done in the open air, and in a number of more or less widely separated places on the same evening. The photometer must, consequently, be readily portable, and at the same time must be provided with a special lantern to protect the standard light from draughts, and with screens to cut off all extraneous light.

To meet these points I have constructed my photometer as follows : The graduated bar is fastened by a pin passing through one end to the edge of a thick board which serves as the base of the instrument. On this pin it moves freely

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in a vertical plane. At a convenient distance from the pivoted end a graduated circular arc, of some 50deg., is attached to it in such a position that when the bar is raised, the arc plays in a slot in the edge of the base board. By means of a thumb-screw the arc can be clamped to the base at any point, and thus serve both as a support for the bar at any angle above the base and as a means for determining this angle by the reading of the graduation. The base has fastened to it a carefully adjusted level. The lantern containing the standard light is mounted on the base just beyond the pivoted end of the bar. When a measurement is to be made, the photometer is first brought into the same vertical plane with the electric lamp, and the base accurately levelled. The bar is then raised until it points directly at the lamp, and clamped in this position. The carrier, with its Bunsen screen, is then mounted on the bar together with blackened diaphragms, which serve to cut off all light except that coming from the standard and the lamp to be tested. If the night is a dark one, and other lights not too near, no further precautions in the way of screens are necessary; otherwise, the photometer is mounted in a covered wagon.

After the readings have been made [giving the distances of the Bunsen screen from the zero mark at the pivoted end of the bar], the horizontal distance from the zero mark to a point vertically beneath the electric light is measured, and the angular elevation of the photometer bar is read on the graduated arc. From these data the direct distances from the screen to the electric light are readily calculated. The corresponding distances from the screen to the standard are obtained afterward by placing the bar at the angle noted and measuring directly from the screen [at its reading] to the point which the standard occupied in the out-door work.—*American Gas Light Journal.*

THE LIGHTING OF THE CITY OF DUBLIN.

On the 6th inst. Major F. A. Marindin, R.E., sat in Dublin to hear an application by the Alliance and Consumers' Gas Company for permission to open certain streets in the city for the purpose of laying electric lighting cables for lighting of private houses. The streets proposed to be opened were: Nassau-street, Grafton-street, Kildare-street, Dawson-street, Merrion-square, W., Upper Merrion-street, Anne-street, Duke-street, Frederick-street, and Molesworth-street. The gas company contended that under their Acts of Parliament they required no license and no other permission than the one they sought. The Corporation opposed the application.

Major Marindin said this enquiry was of a novel character. The ordinary enquiry was where a company was seeking by means of a provisional order to get power to supply electricity or water where the local authority withheld its consent. In this case the company was moving the Board of Trade to exercise certain powers which they said they had under their Acts, but he should treat it as if it were an ordinary case, and ask the gas company to give him any reasons they could why the Board of Trade should exercise those powers. Of course, he had nothing to do with the legal interpretations of these sections.

Mr. George Wright said he would open the case for the gas company very briefly. The Act of 1866 was the one by which the Alliance and Dublin Consumers' Gas Company was formed for the purpose of "making and supplying gas and other improved means of lighting for public and private purposes"; and certainly, having regard to the fact that electricity was at that time, though not used, well known as a light much talked of and looked forward to, it had always been maintained by the company that under that they had the power of supplying electric light. That was the fifth section. The sixth section limited the area within which the company could supply this light to the whole of the Metropolitan Police District, a number of townships adjoining Dublin, 13 altogether, and the township of Bray and Powerscourt, in the county Wicklow. In 1883 the company went to Parliament to get powers to raise a capital of £286,000. About that time the company purchased the plant of the Dublin Electric Lighting Company, and had since been supplying light to a number of firms in the city, their right to do so never having been questioned. It had been supplied by overhead wires, but to that system there were many obvious objections, and it was necessary that the company should have power to open up the streets and lay them underground. Under the Act of 1866 and other Acts, the gas company had power to open the streets for all the purposes of their Acts; while the streets were closed by the Corporation and the expenses charged to the company; and if the legal position of the company was right, that they had the power to supply electric light also, it would follow, and they had been so advised by eminent counsel, that they had the same power, or at all events up to the Act of 1883, to open up the streets for the purpose of laying these electric wires. By the Act of 1883 a certain restriction was imposed on them which made this enquiry necessary. That restriction did not take away from them the power to open up the streets, but said that they should not be at liberty to do so without the permission of the Board of Trade, who might impose such conditions for the public safety as to them might seem reasonable. The Corporation of Dublin had already got a license for public lighting, and had power to open the streets wherever they liked, and the gas company only asked the same permission for private lighting. The scheme the company brought forward was this. Of old capital there remained £13,000—that was of the capital raised in 1866; that capital was not tied up in any way, not subject to any restrictions, and was now applicable to any scheme of electric lighting that they might devise. They had a former sum of capital under the Act of 1883 of £383,000; that they could not touch without getting the sanction of the Board of Trade, for the 25th section of that Act provided that it should not be applied to the supply of electricity without the sanction of the Board of Trade. It might be that in the future they would ask for that sanction, but in the present application they did not. As to any excess in the present estimate over the £13,000 capital there would be no difficulty about raising it. As to the works themselves, the area was a rather populous, busy, and wealthy part of the town, where there was a very great demand for electric lighting. The Corporation could be only opposing this on one ground, that they wished to get a monopoly of private lighting as they had of public. Monopolies were at all times offensive, and the Act of 1888 apparently condemned monopolies in electric lighting as strongly as anything could. They had had numerous applications from persons living within the proposed area to supply them, but they could not do so at present without risk by the system of overhead wires.

During the further course of the enquiry it was stated that about £3,000 was given for the plant of the Electric Lighting Company, which originally cost some £13,000 or £14,000, and the gas company had since spent £4,000 or £5,000 in providing a new plant.

Mr. Arthur Porte, electrical engineer, explained the scheme of the gas company. In the area proposed to be taken in there were about 600 houses, a large number of public institutions and clubs. They supplied at present with electric lights Pim's, Clery's in O'Connell-street, Wright's, Westmoreland-street; Mitchell's, Grafton-street; Bolton's, North's, Dunne's, the Gaiety Theatre, and Powell's, William-street. Within the last year they had received applications from 34 or 35 separate houses for a supply of the electric light. The scheme would cost from £13,000 to £16,000. The Electric Lighting Company charged 5d. an hour for an arc lamp, the gas company charged 8d., but in one case where they had a large consumer they charged less; for incandescent lights the electric company proposed to charge ½d. an hour, the gas company charged 1d. He had no objection to the Corporation and the gas company operating in the same area.

A number of gentlemen having given evidence in favour of electric lighting, Prof. Forbes, F.R.S., deposed he had examined the scheme prepared by Mr. Porte; he believed the estimate was very closely accurate. The plan was a very good one indeed, and would work very well; it would be a most thorough and satisfactory working of the district, very much more so than one was accustomed to see.

Mr. Walker then opened the case for the Corporation. There was nothing in any Act of the gas company to authorise them to supply electric light without coming to the Board of Trade in the usual way. The Corporation were the local authority for the whole city, and had already obtained a license for public lighting; they intended to proceed and obtain a license for private lighting, and they had unlimited powers of borrowing. Now, what was the position of the gas company? They had exhausted all the capital which might have been applied under the previous Acts—if they were right—to electricity, and they now intended to borow under an Act which prevented them applying any of the money to electricity, and they would put that capital in place of the old. It was an extraordinary proposition that a gas company should, out of the city, pick out this little bit of residential portion and apply a limited capital of £12,000 to it, leaving the less wealthy district to be supplied by the local authority. Would the Board of Trade sanction a scheme which never could go beyond that limited area? Was it to be supposed that the company would run this electric light against the gas supply; and, having on one hand a gas supply yielding 10½, and on the other this novel experiment of electric light, was it not obvious that their object was to smother the electric light in its cradle? He submitted that the application was wholly illegal, and should be refused.

A variety of evidence having been offered, Major Marindin said he would make his report to the Board of Trade in due course, and the proceedings terminated.

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ALTERNATE CURRENT WORKING.*

BY W. M. MORDEY.

(Concluded from page 460.)

The paper of Profs. Ayrton and Perry, read last year before the Physical Society,† showed that the efficiency of glow lamps is the same for both direct and alternating currents. The authors of that paper did not directly allude to the question of relative efficiency with different periodicities, but they evidently had this point in their minds, as the periodicities used in the experiments appear to have been varied from 83 to 226 without showing any difference in efficiency. It may be taken, therefore, that no difference exists. Probably for very low periodicities this would not hold good, but for ordinary rates the question may be considered settled. At very low rates the temperature of the filament would follow to some extent the changes of the current, and would be affected both in life and in efficiency. I suppose that at ordinary rates there is no variation of temperature, the filament acting as a kind of thermal flywheel, maintaining its condition unchanged throughout the whole period. We all know, for instance, that especially with low-resistance lamps, when the current is interrupted the time occupied in cooling down to blackness is quite appreciable. The periodicity at which the temperature begins to follow the variations of current is a point of some interest, and it is one that can be very easily investigated.

There is, as far as I am aware, no available evidence regarding the life of lamps with different rates, or even as to the relative life with direct and alternate currents. At one time it was considered that alternate currents would give better results than direct currents, because with the latter there was supposed to be some transference of the material of the filament in the direction of the current. Nothing has transpired to confirm or to disprove this supposition, and, as the number of lamps now in use on each system is enormous, the very absence of evidence may be taken as affording a strong presumption in favour of the belief that the life of lamps is independent of whether the current is direct or alternating, and independent also of the periodicity, within practical limits.

Alternate-current arc lamps are not seriously affected by variations of periodicity within a fairly wide range. The feeding current of a parallel Brush alternate-current lamp remains sensibly constant between 75 and 125 periods, but with the lower rate a slightly higher impedance or resistance is required to secure steadiness of the light.

Secondary E.M.F. of Transformers.

The best potential difference to be used on transformer circuits has been a good deal discussed, especially with reference to the voltage of lamps. It is very desirable to arrive at some conclusions on this matter, not only as to glow lamps, but as to the general question.

The balance of opinion—which is, however, not very decisive—appears to be in favour of using 50-volt rather than 100-volt lamps, so far as durability of the lamp is concerned. The stout low-tension filament should last longer than the finer one for high tension, because disintegration does not so soon reduce the cross section to the breaking point. It is, however, not a question only of life, as the disintegration of the thick filament causes blackening of the globe; and if it can be shown that this blackening, and the consequent lowering of the effective light, is more serious than in 100-volt lamps, then the advantage of slightly longer life will not of itself be sufficient to recommend 50-volt lamps in preference to others of higher voltage.

Of course, the most serious objection to lowering the voltage is the increased cost of the secondary conductors. This is not important in small and very compact installations such as can be so readily supplied by transformers—for instance, in small shops and ordinary houses, where a separate transformer may be placed within a few yards of the lamps, and where the fall of potential is negligible; but for larger work it is advisable to keep the potential difference high, as with direct currents, and for the additional reason that the use of very large alternate currents, with correspondingly large conductors, is accompanied by the inconveniences arising from the high virtual resistance already alluded to.

It is impossible, however, to choose an E.M.F. that will meet all requirements. For instance, high candle-power lamps are coming largely into use, and as this practice extends, higher E.M.F. will be demanded in order to keep down the diameter of the "stick."

But, on the other hand, lamps of small candle-power can be more easily made for low than for high voltage; and as there is a growing tendency to use small candle-power lamps which in many situations give all the light that is required, this point should be kept in mind, especially as it is very probable that before long a demand will spring up for lamps of three or four candles. I know it will be said that it is easy to reduce the candle-power of ordinary lamps by inserting an impedance coil in the circuit. This is one of the many conveniences of transformer working, but it should not be resorted to for permanent purposes, as, however little power such a coil may absorb, lamps reduced in that way, being worked at less than their normal candle-power, are very inefficient.

Then there is another reason for sometimes preferring 50 volts to 100 volts that I should like to mention, and that is that alternate-current arc lamps do not require more than 50 volts terminal pressure. It may be expected that many such lamps will be used on transformers—for instance, at small business places, where perhaps the bulk of the lighting will be internal and by incandescence lamps, but where it will be convenient to have one or two arcs outside. We know that when arcs are used in parallel with incandescence lamps on direct-current circuits, it is necessary, in order to get the best results, to have 12 to 15 volts drop of pressure in a fixed resistance in series with each arc. Thus has arisen the custom of using 65 volts for mixed arc and glow lamp circuits, where the potential difference at the arc lamp terminals is reduced to about 50 volts by the insertion of such a resistance, the incandescence lamps, however, being made to work at 65 volts.

This is a very wasteful arrangement, but, apart from its wastefulness, 65 volts is a very inconvenient pressure both from the manufacturer's and the consumer's point of view. It does not lend itself to combination as does a pressure of 50 volts dynamos, lamps, or transformers, for 65 volts cannot be used in pairs on 100-volt circuits as can such apparatus for 50 volts. It is an irregular and inconvenient pressure that is demanded by the necessities of direct currents, but that I am glad to be able to say need not be imported into alternate-current work.

This very serious loss can be almost entirely avoided with alternate-current arcs, as the necessary steadying effect is readily obtained by the use of an impedance coil, absorbing much less power than does a resistance; and as such arcs require only 35 to 40 volts between the carbons, instead of 45 to 50 with direct currents, it is sufficient to provide 50 volts potential difference between the secondary conductor.

But it may be said that, as impedance coils absorb little power, the arc lamps may be put on 100-volt circuits in parallel. This may be done without much objection so far as the lamp and impedance coil are concerned, but there is the drawback that the "plant-efficiency" of the transformer will then be low.

The output of a transformer is limited partly by the size of the conductor. The actual output of a 100-volt transformer supplying arcs through impedance coils will not be much more than the product of the current × 50 volts, while for the same output in watts on glow lamps it would only have to yield about half the current. Therefore we see that, although not inefficient, the maximum allowable output of a 100-volt transformer on parallel arc lamps is only about one-half of its ordinary maximum output.

It will be said that two arcs may be run in series on the 100-volt secondary. This is true, but two arcs are not always wanted; and, further, the working of two arcs (which must for this purpose be shunt or differential, instead of simply series-wound) in series on a constant potential difference is the least satisfactory way of arranging arcs, whether for direct or alternate current, as in this way they affect one another the most, having neither the margin of controlling power by current, which is provided in the parallel constant potential difference arrangement, nor by E.M.F., as in the series constant-current arrangement. Then, again, lamps so connected must be extinguished together, as no cut-out or switch can be used unless it is made to insert a resistance or impedance to take the place of the extinguished lamp.

On the whole, therefore, it is preferable to have 50-volt secondaries where arcs are to be used, or to adopt the intermediate plan of connecting the middle of the 100-volt secondary to a third terminal, using a third wire for any arcs or 50-volt lamps that may be required. It may be worth while to point out that the use of a third wire on transformer circuits may lead to difficulty if not carefully considered. With a single transformer it is as easy to use three or any other number of terminals for the lamps as it is to do so on a set of accumulators, and to get any corresponding potential difference. The various sections of the secondary may be unequally loaded by this arrangement, but the primary responds as a whole to the demand made upon it. If, however, instead of a single transformer, two transformers are used, with their primaries and secondaries respectively in series, then the use of the three-wire principle is only possible when it is applied to both the primary and secondary circuits, unless the load on each of the two secondaries is always to be alike and the same, in which case, as scarcely need be said, there is no particular advantage in using three wires. If the loads are not equal on the two, then the primary of the least loaded transformer acts as an impedance coil to the other primary, and all power of self-regulation is lost. One remedy for this is to apply the three-wire principle to the primary as well as to the secondary; but this is a serious matter, and one that could only be undertaken where the whole service demanded it. Another plan is to have two mains for the primary and three for the secondary, and to join the primaries parallel, the secondaries being in series with the third wire at the middle terminal.

In cases where arcs have not to be used, and in the absence of any very strong evidence of any difference of life in favour of 50-volt lamps, I think it is best to use 50 volts for small separate installations, and 100 volts for larger ones; but it is evident from what has been said that there are so many points to consider that it is quite impossible to give any definite negative or affirmative reply to the question, "What is the best secondary E.M.F. to use?" Each case, or at least each class of cases, must be settled on its merits. If for general convenience any particular pressure is selected, it is obvious that it will have about equally strong arguments for and against it.

Alternate-Current Arcs.

Reverting to this subject, it is to be regretted that very little appears to be commonly known about A.C. arcs. I trust that in the discussion of this paper some information may be furnished with regard to them.

As to the regulating mechanism of lamps, although some difficulties were encountered in modifying the Brush arc lamp for this work, the result has been perfectly satisfactory. The feeding range is very small—quite as small as with direct currents, and with no greater loss of power in the lampbox. Some trouble was experienced in getting rid of noise and vibration in the coils and mechanism, but this has been completely overcome, the lamp itself being quite silent. This is readily proved by connecting the carbon-holders by a flexible wire and adjusting the current to the normal value, when it is found that

* Paper read before the Institution of Electrical Engineers.

† *Jour.* Phys. Soc., vol. ix., p. 208.

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there is no noise. An A.C. arc is not silent, as is well known, a distinct hum being set up, by which it is quite possible to ascertain the periodicity.

This humming noise, which can scarcely be expected to be overcome, renders A.C. arcs unsuited for general use indoors; but for outside illumination, and for such places as railway stations, they will certainly find a very extensive application.

I venture to think that the opinion so often expressed, that A.C. arcs give much less light than those supplied with direct current, is founded on a misunderstanding of the proper conditions. It is quite true that if two arcs are compared, supplied with the same amount of current, the direct-current lamp will prove the better one. This, I think, is because the basis of comparison is not right. In many cases the A.C. arcs are more efficient. They should be judged by the energy, and not only by the current. I have mentioned that an A.C. arc requires only 35 to 40 volts potential difference between the carbons, while a direct-current arc requires 45 to 50 volts. The mean may be taken at 37·5 and 47·5 volts respectively, and to expend the same energy in the two cases the current should therefore be in the inverse ratio of these values. Thus an A.C. arc, to give the same light, and to absorb the same power as a 10-ampere direct-current arc, should be made for 12·6 amperes.

In one respect A.C. arcs are inferior, and that is in their power of directing the light downwards. They have no "crater," and, therefore, do not send the light down as do direct-current arcs. On this account it is advisable to use reflectors above them, unless they are suspended below and near a good reflecting ceiling or roof.

But even this drawback is counteracted in parallel work by their greater efficiency. On a 65-volt circuit with direct currents, as I mention elsewhere, there is a waste of 100 to 150 watts with a 10-ampere arc, and in the same proportion with other currents. This is a very serious proportion of the whole power, and it is only allowable to waste it because, as a light-producer, the arc is so much more efficient than the incandescence lamp. Nevertheless, any means of avoiding the loss is to be welcomed, and with A.C. arcs it may be greatly reduced by the use of impedance coils, which, if properly designed, waste very little power, and have all the steadying effect of resistances.

Safety and Safeguards.

I take this opportunity of bringing up this question, not because I have anything new to say with regard to it, but in order, if possible, to bring it a little nearer to a rational settlement.

It will be acknowledged that the first duty of an "undertaker" using high tension is to provide for the complete and absolute safety of the consumers. If there are no means of doing this, then the system is fundamentally bad, and must sooner or later be abandoned.

There are several ways of protecting the house mains more or less completely. I only need allude to three typical plans, all of which have already been discussed before this Institution.

One is the plan introduced by Mr. Kent, of entirely separating the primary and secondary conductors in a transformer by a sheet or division of earth-connected metal. This is open to adverse criticism on some points, but on the whole it is an effective plan.

Another arrangement is the ingenious one of Capt. Cardew, consisting of a sort of static mousetrap, which immediately goes off when an unauthorised P.D. enters it.

The third plan is that of earthing the secondary, and it would be very instructive if those who so strongly oppose this plan would state just one real objection to it. It is a perfectly sure method, and costs nothing.

It renders it absolutely impossible for the consumer to get a dangerous shock under any possible combination of circumstances whatever.

The faults that may occur are (*a*) Contact between primary main or mains and earth. (*b*) Contact between primary and secondary in a transformer. (*c*) Contact between a person and a portion of the secondary conductor. (*d*) Contact between that person and earth.

Now, if all these contacts occur at the same time, the "person" will get a shock.

But if the secondary is earthed, no shock can be obtained, except, perhaps, a slight one, due to the secondary P.D.

This simple plan has been approved by almost everybody, but it is received with opposition on the part of some of the fire insurance offices and others.

It is difficult to ascertain where the supposed danger is. If the secondary is earthed, the effect of a contact between primary and secondary, when the former is accidentally leaky, is at once to blow out the primary safety fuse of the transformer, and so cut out the offending house. This is the simplest and the best course to take, and prevents the continuance on the circuit of transformers that contain faults.

The Brush Corporation has adopted this plan with perfect success on a large installation abroad, and intends adhering to it where local circumstances permit.

It is to be remarked that it is not open to the objection that has been stated against earthing of one of the primary conductors—viz., that the telephones may be affected—for it is not permanent. The moment a contact occurs that could lead to a disturbance of the telephones, the fuse prevents that disturbance being continued.

While effectually removing life risks, this precaution does not increase fire risks; in fact, it tends to greater safety, as it is some sort of check on the character of the house wiring work, and so reduces chances of faults, such as short-circuiting of the secondary.

The rupture of a primary safety fuse is not a serious matter, and in any case it is only what takes place under ordinary circumstances when any fault occurs that results in an excess of current.

As to static effects, I think it will be found that there will always be enough general leakage to prevent such effects being a cause of difficulty, even if the secondary circuits are not earthed.

Hysteresis and Eddy Currents.

Some explanation is necessary by way of preface to this section of the paper. The experiments described were made with a direct-current dynamo, and on that account they only touch the fringe of this division of the subject. As I had no suitable alternator, I was unable to pursue the question as far as I wished to do, but I hope I need make no apology for bringing forward such results as I have been able to arrive at.

As far as I am aware, no simple or practical method is known by which the power absorbed in eddy currents can be determined and separated from that due to hysteresis in the armatures of dynamos. This is a point of some importance, both as regards alternators and direct-current machines, for many reasons, one of the principal being that in the absence of exact knowledge on these matters it is difficult or impossible to determine to what extent the lamination of the iron cores should be carried. There are wide differences in the practice of the various designers and makers of dynamos in the thickness of the iron used.

Lamination may be carried to such a degree of fineness for the purpose of reducing eddy currents as to add very materially to the cost of production, the iron increasing rapidly in price as the thickness is reduced; and it may be that the point is sometimes passed beyond which no gain in efficiency is obtained. This is a question we wish to be enabled to settle.

Until Prof. Ewing* and Dr. J. Hopkinson† read their Royal Society papers on the subject, very little was known of the heating effect of changes of magnetism. Prof. Ewing opens the part of his paper dealing with this matter in the following terms (p. 552, *Phil. Trans.*): "The energy expended in a cyclic process of magnetisation can take no other form than that of heat diffused throughout the substance of the metal. Experiments have been made by Joule and others to determine by direct observation the heating effect of magnetisation in iron.‡

"In most direct measurements of this quantity no distinction is made between the heating effect due to the induction of electric currents and that due to changes of magnetisation *per se*; and so excellent an authority as Prof. Rowland, writing in 1881, has expressed himself as doubtful whether changes of magnetisation, considered apart from the currents they induce, give rise to any development of heat at all."

Further on, Prof. Ewing, referring to the dissipation of energy by hysteresis, which he had determined by laboratory experiments, says, (*Phil. Trans.*, pp. 553, 554): "These developments of heat are so small as to make it apparent that the very considerable thermal effects which reversals of magnetism cause in the revolving cores of some dynamo-electric machines must be due almost wholly to the internal induction of currents, so far as they are not due directly to the current circulating in the coils of the armature.

"The experiments have a practical value in showing that cores which are so thoroughly laminated as to render the induction of currents within them unimportant, do not involve any serious loss of energy; and that the efficiency of a machine with a soft iron core or cores whose magnetism is periodically reversed need not, on that account, be materially less than that of a machine which has no such cores. The absence of iron from the armature has been claimed, on the score of efficiency, as an important advantage possessed by some types of machine, but unless the claim has some other basis it appears to me to be illusory. Magnetic reversal does involve some loss of energy, but if the cores are properly laminated it is so small as to be practically insignificant."

I quote these passages as showing the position of the question. Prof. Ewing and Dr. Hopkinson give laboratory determinations of the magnetic loss in iron with various inductions and under various conditions. It is, however, left somewhat in doubt as to whether the loss in dynamo armatures will be the same as in the laboratory experiments, the conditions being very different in the two cases.

On this point Prof. Ewing shows that hysteresis is much less when the iron is in a state of mechanical vibration than when it is in a state of rest, and states that in a dynamo the loss will be less than the experiments on still metal might lead us to expect.

Another way in which the dynamo conditions may cause some difference is the possible variations of the magnetic density that may exist in the core. Such variation may be considerable in armatures of large size.

Dr. Hopkinson (*Phil. Trans.*, p. 467) takes the magnetic loss in armatures as being the same as in the small pieces of iron tested by his method, and gives an example calculated for an armature-core "finely divided, to avoid local electric currents."

It is to be noted, then, that both these authorities regarded eddy currents as unimportant in laminated armatures; but in the later paper on "Dynamo-Electric Machinery,"§ Drs. J. and E. Hopkinson published their famous investigation into the efficiency of dynamos, and gave very full particulars, from a study of which it is possible to ascertain the loss in eddies, on the assumption that the method of calculating the magnetic loss is correct when applied to armatures—a point which Dr. Hopkinson was not able to decide positively; but by assuming that it is applicable, then, by subtracting the calculated hysteresis loss from the ascertained total power unaccounted for, the eddy-current loss is obtained; and as this process gives the hysteresis as accounting for only about 40 per cent. of the total loss in the arma-

* Prof. Ewing, "Experimental Researches in Magnetism," *Phil. Trans.*, January, 1885.

† Dr. J. Hopkinson, "Magnetisation of Iron," *Phil. Trans.*, April, 1885.

‡ Joule, *Phil. Mag.*, vol. xxiii., 1843; Grove, *Phil. Mag.*, vol. xxxv., 1849; Villari, *Nuovo Cimento*, 1870; Cazin, *Ann. de Chim. et de Phys.*, 1875; Trowbridge, *Proc. Amer. Acad. of Arts and Science*, 1879.

§ *Phil. Trans.*, part 1, 1886, p. 331.

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ture core, it shows that the eddies could not by any means be considered unimportant, although the lamination was carried out to the extent of making the iron about 0·02in. thick.

I now wish to describe a method by which the amount of loss due to each of the two causes may be ascertained experimentally in the workshop on a practical scale. It is a very simple one, although not, perhaps, capable in all cases of the highest scientific accuracy.

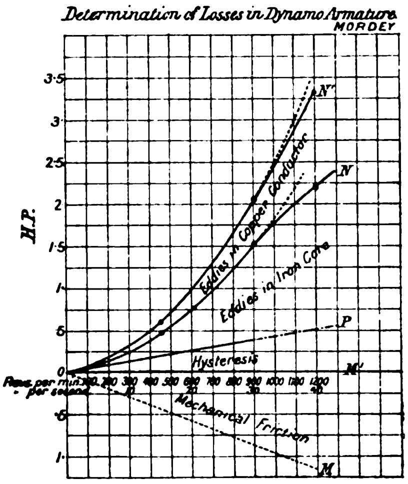

FIG. 3.

(*a.*) First run the dynamo on open circuit at various speeds (two readings will suffice), with the fields unexcited, or, better still, entirely absent, and measure the power absorbed in friction. Plot this value to any suitable scale, as O M in Fig. 3, the ordinates representing horse-power, while the abscissæ represent revolutions per minute.

In the figure the mechanical friction, being a quantity with which in this investigation we are not directly concerned, is plotted below the base line O M', in order that the other losses may be more clearly seen.

(*b.*) Next, run again on open armature circuit with the brushes removed, and the field normally excited, and measure the power absorbed. This will be the total power dissipated in friction, hysteresis, and eddy currents, if any, and must be plotted as O N. Then the ordinates lying between O N and O M' represent the sum of the losses due to hysteresis and eddy currents, and somewhere between O M' and O N must lie a line O P, separating the hysteresis from the eddy currents.

We desire to find the position of this line. The difference between the rate of increase of the electric and magnetic losses enables us to separate them from each other. It may be taken that with any given constant excitation the loss from hysteresis is directly proportional to speed, within certain limits to be hereafter stated. The resistance (that of the iron) being constant, the eddy currents must vary as the first power of the speed, and the loss therefrom as the square of the speed.*

It will now be seen that it is easy to separate the values which are directly proportional from those which are proportional to the square of the speed.

Prof. S. P. Thompson, to whom I submitted this method, has kindly given me the following concise formulæ for finding the quantities :—

P and P_1 are respectively the combined magnetic and electric losses at the speeds S and S_1.

k = magnetic loss ;

k_1 = electric loss.

$$k = \frac{P_1 S^2 - P S_1^2}{S^2 S_1 - S S_1^2};$$

$$k_1 = \frac{P S_1 - P_1 S}{S^2 S_1 - S S_1^2}.$$

Then, at any speed n,

Hysteresis $= k\,n$;

Eddies $= k_1\,n^2$.

If armature cores are run in an excited field before winding, it can be determined to what extent their lamination is satisfactory, and whether the iron is of good quality ; and then, after winding the armature-conductors, another test shows what the additional increase in the loss is, and separates the effects of eddy currents in the core from those in the conductor, and the hysteresis from both. The method may also be useful to investigate the losses in the cores of armatures of different types, or differently built up, as for instance, with iron wire or iron sheets.

This method has a useful application in rendering it possible to separate not only the magnetic loss from the electric loss in the iron, but to determine the waste by eddies in the copper winding of armatures.

It is usually entirely a matter of opinion as to how much of the power absorbed in running an armature on open circuit is due to any of the various causes referred to ; and now that it is customary to wind armatures with heavy conductors, it becomes very desirable to be able to find in any particular case what proportion of the loss is in the copper, and what in the iron.

* Prof. Thompson's ' Dynamo-Electric Machinery." Third edition, p. 102.

In Fig. 3 are shown some results obtained with a four-pole (direct-current) Victoria dynamo run at various speeds up to 1,200 revolutions per minute, with constant excitation. Power readings were taken by means of a White's transmission dynamometer, constructed by the Brush Corporation for the purpose of testing dynamos ; and the horse-power absorbed in mechanical friction in dynamo, belt, and dynamometer was subtracted from the power spent electrically and magnetically.

To reduce errors in the dynamometer readings the dynamo was fitted with two pulleys, one twice the diameter of the other. This allowed of the dynamometer being run at the same speed, while two different speeds of the dynamo were obtained by changing the belt from one pulley to the other. Readings were taken at four speeds—viz., 450, 600, 900, and 1,200 revolutions per minute, corresponding to 15, 20, 30, and 40 periods per second. The position of O P was readily found by "trial and error," this being a shorter process for a concrete instance than the application of the general formulæ. The assumption on which this method of testing is based was found to be correct up to 900 revolutions. The reading at the higher speed of 1,200 revolutions, or 40 periods, shows that disturbing influences began to affect the results by reducing the rate of increase of the losses. The continuation of the curve, O N, in a full line shows the actual loss, while the continuation in a dotted line, which is a parabola on O P as an abscissa, shows what the loss would be if the rate of increase holding for low speeds were maintained.

This shows that this method is perfectly applicable to ordinary direct-current machines—for instance, to two-pole dynamos up to 1,800 revolutions per minute, or 30 periods per second—but that it is less useful for alternators.

The disturbing causes are probably rather complicated. They may be due partly to self-induction in the circuits of the eddy currents, to lower magnetisation (although this effect, if present, is very slight, as was shown by the E.M.F. being almost perfectly proportional to speed), and to vibration. "Viscous hysteresis," if it exists, will raise the magnetic loss. There may be such an effect in spite of the lowering of the curve, but it cannot be recognised, on account of the unknown variations of the eddies, at the higher speed. Iron-cored alternators working at high periodicities may be tested in the following way, which will give some approach to correct results : Let the test be taken at a low speed (not more than 30 periods). This will give the hysteresis per period, and the eddies at that speed. Then, if at any higher speed the E.M.F. is proportional to speed, it may be assumed that the magnetic induction is the same as before, and the hysteresis per period will at any rate not be less than at the lower speed. It may be more. The difference between the calculated hysteresis, O P, and the ascertained total loss, O N, will be the eddies ; or, if viscous hysteresis is a fact, it will be extra loss due to viscosity plus that due to eddies.

Heating of the armature-core, and consequent increase of the resistance of the iron, is not responsible for the bending down of the curve O N in Fig. 3 (although it would have that effect under ordinary circumstances), as the experiments did not occupy sufficient time to allow of any sensible rise of temperature. The effect is probably very complex and obscure, but it is one that well deserves study, on account of its present industrial importance.

It should be stated that the dissipation of energy (which has been spoken of as being in the armature) may be partly in the field-magnets. This was, however, not the case in the experiments referred to The conditions necessary for the prevention or reduction of eddies in the iron of field-magnets are now pretty generally understood ;* but it should be observed that it is not by any means as easy to check such waste in alternators as in ordinary dynamos. It is both better and easier to prevent than to cure them.

If a good transmission dynamometer is not available, results almost, or perhaps quite, as good may be obtained by running the machine at various speeds by means of an electric motor, and measuring the power required by the motor—first with the fields of the machine unexcited, to get the mechanical friction, and then with the fields excited, to get the total loss. The motor should then be run alone, to find what is absorbed in driving it at various speeds. The increase in watts over these last values, with the internal losses in the motor-conductors calculated out and subtracted, will give, with a very fair degree of accuracy, the energy dissipated in the machine under test.

The upper curve, O N', was plotted from readings taken after the armature was wound, and the difference in the ordinates between O N and O N' shows the eddy-current loss in the copper conductor at various speeds. This loss, like that of the eddy currents in the iron, rises as the square of the speed up to 900 revolutions, or 30 periods, above which it rises rather less quickly. The full line, O N, shows the actual loss, the dotted line above it showing what it would be if the rate of increase were maintained. The difference is no doubt due to self-induction.

That the effect of self-induction is not noticeable unless the eddy currents are considerable is in accordance with experiments that I published some years ago in connection with the Brush dynamo. The results then obtained are shown in Fig. 4. The straight line connects speed and the potential difference at the terminals with the laminated armature ; the lower and slightly curved line shows the potential difference with the old form of cast-iron armature, which had only coarse divisions, scarcely meriting the term "lamination." The curve shows that the E.M.F. rose less quickly than the speed on account of the serious generation of eddy currents.

In the laminated armature, although, of course, there were still eddies, their effect was not sufficient to cause any bending down of the E.M.F. line at any practicable speed of driving.

Coming now to an examination of the results obtained in the

* See numerous practical notes on this subject scattered through Prof. Thompson's "Dynamo-Electric Machinery."

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experiments, and shown in Fig. 3, we see that the hysteresis loss in this particular dynamo—which I should mention is capable of working continuously with a normal load of 18,000 watts—was 0·195 h.p. at 450 revolutions, and 0·39 h.p. at 900 revolutions, the latter corresponding to 30 periods per second.

The magnetisation* was about 12,300 C.G.S. lines—not by any means a high density. The armature had a ring core, nearly square in cross-section, of 12 square inches area, and contained 615 cubic inches, or 10,096 cubic centimetres of iron strip 0·012in. thick (No. 30 B.W.G.) separated by paper. This is a degree of lamination beyond which it is inconvenient to go. The pheripheral portion was wound with this iron in parallel bands ½in. wide, in order to reduce eddies caused by lines entering the periphery. The main inner portion of the core was of wider strip.

We find from the figures that the loss in hysteresis at 900 revolutions was as follows:

0·39 h.p. = 291 watts = 0·473 watts per cubic inch, or 0·029 watts per cubic centimetre. As the periodicity was 30, the dissipation of energy per complete period per cubic centimetre was 9,613 ergs or 0·001 watts, nearly.

It is interesting to compare this result, obtained in what may seem a rather crude manner, with the values given in the papers referred to. Prof. Ewing says (*Phil. Trans.*, p. 553) ". . . the double reversal of a strong condition of magnetism in soft iron involves the expenditure of about 10,000 ergs per cubic centim." He gives the energy as 9,300 ergs, with a magnetisation of 13,190 in very soft annealed iron. Dr. Hopkinson gives 13,356 ergs, with a magnetisation of 18,250.

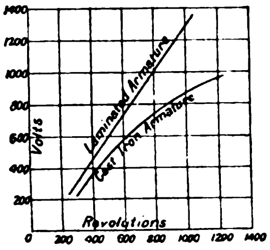

FIG. 4.

a a, Armature Coils; *b b*, Field Poles.

FIG. 5.

Much of course, depends upon the quality and hardness of the iron, but my results come out very close to those of Prof. Ewing and Dr. Hopkinson. This may be taken as proving the method capable of considerable accuracy. The eddies in the iron, it will be seen, are by no means to be neglected, even with the very fine subdivision that was used.

The eddies in the conductor are rather greater than usual, as the armature, being intended for a very low speed, had a larger amount of copper on it than usual.

The bearing of these curves on iron-cored alternators, and on open circuit working generally is obvious. With a magnetisation of 12,000, the loss in hysteresis alone, at 100 periods, would be over 1·5 watts per cubic inch of iron core, and the eddies would amount to a good deal more. I will only add that the eddies, both in the iron and in the copper, are greatest when no external work is being done, as was the case in my experiments. They are reduced by the effects of self-induction when the circuit is closed. A difference exists in this respect between generators and motors, a difference in favour of generators.†

I will not further extend this paper by dealing at greater length with this part of the subject.

APPENDIX.

Extract from remarks by Mr. Mordey in the discussion on Mr. Kapp's paper on "Alternate Current Machinery."—*Proc.* Inst. C.E., March 5, 1889.

"Alternators might be divided into two classes—those which had iron in the armatures, and those which had not. As his own machine, made by the Brush Corporation, and that of Ferranti were the only examples of the latter class described by the author, he might be permitted to mention the reasons which had led him to avoid the use of iron. He thought the makers of dynamos would agree that almost all the ills that the dynamo was heir to were due to the presence of the iron in the armature. Its use in direct-current machines might be said to be a necessary evil, as, although attempts had been made to do without it, all successful types of such machines required it for structural purposes. Iron in armatures, when worked at a high magnetic density, and with rapid reversals or variations of magnetisms, became heated, and wasted a good deal of power. In alternators, this objection applied with very much greater force than in direct-current machines, for in the latter the reversals of magnetism were comparatively slow. Thus the first result arrived at in quite recent practice is that the magnetic density that can be used in iron-cored alternators must only be about one-half that employed in continuous-current armatures. This alone meant a considerable increase in the size of armatures, without any gain in output or efficiency. Although the loss per cubic inch was reduced by decreasing the magnetic density, the armature had to be made larger to compensate for it, and the total loss was actually increased, not reduced. Iron was used to reduce the magnetic resistance, to afford mechanical support, and to introduce self-induction into the circuit. The latter, an evil in itself was said to be a modern necessity, caused by the convenience of working alternators parallel. Self-induction, for this or any other purpose, had probably not entered the minds of most designers at the time they first produced their machines, except, perhaps, as an objectionable feature, which they could not get rid of; but now it was being brought forward as an advantage. If iron was indispensable for this purpose, which he was not prepared to admit, it could readily be inserted in some part of the circuit where ample space and cooling surface could be provided, and from which it could be easily removed when not required, that was when it was only necessary to run one machine. The armature was the very worst place to put the iron, for there its presence was the most objectionable, and it was there least under control. Referring to the magnetic resistance of armatures, it would be seen that there were broadly two ways of arranging the armature-coils and the field poles. The poles could be arranged north and south, facing one another, the armature-coils having their axes parallel to the lines of force; or the poles could be arranged in successive order round an iron ring or drum armature-core, on which the armature-coils were wound or placed. If iron cores were used in the former case, the output would be only about one-half of what was obtained with air cores, on account of the necessity to work with reduced magnetic density, while at the same time magnetic and electric disturbances would be set up, both in the armature and field, wasting power, causing objectionable heating, necessitating lamination of the fields, and demanding an increase in the exciting power. These reasons were sufficient to explain why he had not used iron cores; but there were others. Magnetic resistance, between pole and pole, was made up partly of the necessary clearance space, partly in most cases of the space occupied by the copper conductors, and partly of the iron or other core. Now, if in air-cored armatures the core could be so arranged, as was quite possible, and was done in his own machine, that it occupied no more space than was taken by twice the depth of the conductors in iron-cored armatures, it would be evident that the former gained instead of lost by the omission of iron. They gained not only in magnetic resistance, but in all the other points to which he had referred, and they had the very great advantage that there was nothing to limit the magnetic density at which they could be worked except the magnetic saturation of the field-poles, the only losses to be met and provided for being the ordinary electrical losses in the conductor caused by the passage of the current, and a small waste by eddy currents in the conductors and supports. Such armatures had the further advantage that their self-induction was negligible, their power of self-regulation was very great, and that on open circuit or light load they ran very economically; whereas it was well known that, when iron cores were used, the losses under such circumstances were often very serious indeed. He thought it was quite unnecessary to use iron cores for the purpose of obtaining mechanical support for the armature-winding. The holding and driving, with a very limited clearance, of an armature consisting of thin iron, separated by such unmechanical substances as paper, and overwound with copper wire, itself covered with cotton, and expanding and throwing out from the combined effects of heating and centrifugal action, was a problem that had never been very successfully solved in direct-current machines, and was certainly to be avoided, if possible, under the still more onerous conditions obtaining in alternators, where the electrical pressure was usually much higher than in direct-current machines, and in which, as the author showed, the maximum mechanical strain on the wires was greater. He ventured to think it was much the best to make the armature stationary as he had done. It then had only to resist the tangential drag of the field. He thought a great mistake was made in some alternators in using Pacinotti projections. In all cases there should be, as nearly as possible, a steady magnetic flux in the field. This could not be done if projections were used. The Zipernowski and Parsons machines were faulty in this respect. It was impossible to tell, by inspection of the former, which was the armature and which the field. They seemed quite interchangeable, and this was, of course, not right. In these two machines, it would be seen that the magnetic resistance varied very much, as the iron projections passed through the cycle. This necessarily led to losses in the field, the lamination of which recently introduced in the Zipernowski machine showing that such losses must be serious. There was one other machine to which he wished to allude, and that was to him a very interesting machine indeed. He referred to the alternator shown and referred to by Prof. Forbes as in some respects a development of his alternator. In that machine Prof. Forbes used the form of field which he (Mr. Mordey) had in his alternator; but he used it in combination with a form of armature having, like the field, only one coil. He ventured to point out that, for a machine with an iron armature, that form of alternator had some advantages. The armature might be described as a Gramme ring, with the copper inside and the iron outside. The magnetic flux was, or might, be made perfectly even, the air-gap was very short, the magnetic resistance very low, and it followed that the excitation required was very small. The author had alluded to a very interesting and important matter, probably new to most people, as it certainly was to him, namely, that the armature-conductors in alternators showed a tendency to heat much more than in the continuous-current machines, but in this machine described by Prof. Forbes there was hardly any question of eddy currents in the armature-conductor, as the coil was not swept by the lines of force. Further, it was evident that a very low current density could be used in the armature-coil without sensibly affecting the size, cost, or output, and it was also clear that the insulation of the armature-coil was a very simple matter. Another good point was that neither the armature-coil nor the field coil need be rotated. For a machine with an iron magnetic circuit he thought this was a very good one; and he had only one other remark to make about it, and that was that he had himself invented and patented it some time ago!

* The use of the word "induction" in so many senses is apt to cause confusion. "Magnetisation" would, perhaps, be better than "induction," "magnetic induction," "density," "magnetic density," etc.

† *Phil. Mag.*, January, 1886, p. 26. "The Dynamo as a Generator and as a Motor."

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It was, he thought, a natural development of his alternator. He was glad to find that Prof. Forbes had had the same idea, because that showed it to be a good one. Much had been said about the form of the wave yielded by alternators. He had some time ago made an experiment with the first of his machines, using the method described by Prof. Ayrton, and found that the curve was almost a sine curve. On the subject of the lag in transformers, to which Prof. Ayrton had also alluded, he might be allowed to mention that, in the discussion of another paper by the author, he had first stated the fact,* and had described a very simple experiment, showing that the primary and secondary currents reached their maxima and minima practically at the same time."

DISCUSSION.

Before the discussion was proceeded with, the author exhibited and described an automatic current regulator arranged to work within ½ per cent. without "hunting," and also explained a model and drawings of his "single coil alternator." During the week he had received letters, amongst others, from Lord Rayleigh, Prof. Ewing, and Mr. Zipernowski, bearing on his paper, from which he now read extracts. Lord Rayleigh pointed out in the *Phil. Mag.* for 1886 he had worked out the virtual resistance of conductors. He also thought the term "frequency" better than "periodicity." Prof. Ewing referred to the work lost in hysteresis, and Mr. Zipernowski promised to forward his criticisms later on.

Prof. Forbes read some notes by **Dr. Hopkinson**, who states that to obtain direct control in parallel working, neither large self-induction nor small self-induction are essential, but the best control is exerted when $\frac{2\pi\gamma}{T}=r+R$, where γ=coefficient of self-induction, T=per period, and r=R is the resistance of armature and leads. If the resistance of the leads or feeders be considerable, parallel working is more difficult. In his paper of November 13, 1884, the case of putting generators giving different E.M.F.'s in parallel was shown to be feasible, and from the equations of § 3 the work done by the leading machine becomes zero when $\frac{2\pi\tau}{T}=\frac{\pi}{2}$ where 2τ is the difference in time phase. Dr. Hopkinson also says that all the phenomena observed by Mr. Mordey could be predicted from his 1884 theory.

In a communication from **Prof. Adams**, read by Prof. S. P. Thompson, attention is directed to the South Foreland trials of 1884, and described in his paper read on Nov. 13 of that year, in which many of the experiments mentioned in Mr. Mordey's paper were performed satisfactorily. He regarded Mr. Mordey's statement on page 4, that alternators with small self-induction and resistance will best run parallel "because they will be the best synchronising motors," as equivalent to "saying that tuning-forks synchronise when in unison." Reference was made to the beats by the synchronising lamp when one machine was running at half the speed of the other, and from acoustical analogues Prof. Adams thinks alternators will run as motors at speeds corresponding to fractions or multiples of that of the generator. He attributes the active cause of synchronising to self-induction, and considers that the groaning heard when the machines were switched parallel to confirm this view.

Major Cardew, referring to the frequency at which the temperature of lamp filaments begin to follow the current, said that in experiments on signal-flashes about ten changes per second could be clearly seen. The section on safety and safeguards seems to him to imply that the faults (*a*), (*b*), (*c*), (*d*), must occur simultaneously if a person is to receive a shock, but the speaker thought (*a*) and (*b*) may exist unknown to a person who accidentally, or otherwise, touches the secondary whilst making contact with earth. Earthing the secondary, though safe as regards shocks, might considerably increase fire risks.

Dr. Fleming, speaking from information recently obtained in Milan, said there was no difference between the average life of lamps worked by direct or alternating currents. As a possible explanation of the observations on the periodicity which gives maximum efficiency, he suggested that for rapid changes the viscous hysteresis was most important, whilst for slow ones the eddy currents penetrated further into the metal, thereby wasting more energy. He thought the Institution was greatly indebted to Mr. Mordey for demonstrating successful parallel working without much self-induction or resistance, and pointed out that to work alternators parallel satisfactorily, not only must the machines come into step, but they must do so promptly, and considerable stability must exist. These conditions may be satisfied by suitably shaping the field-poles and armature-coils, for on these the shape of the E.M.F. curve depends.

Mr. Kapp complimented the author on his valuable paper, not as a formality, but because it was one of the best ever brought before the Society. In his remarks on the paper he thought it was not at all clear how the E.M.F. of a machine excited to give 1,000 volts rises to 1,500 when placed in parallel with one giving 2,000 volts, but, according to his idea, was probably due to the armature current demagnetising the fields of the generator and magnetising those of the motor. He questioned whether the self-induction of the armature was insignificant, for when the field-poles were central with the coils they would act as cores for the coils, which would therefore have considerable self-induction. This will vary with the relative positions of the magnet and armature, and tend to pull the machines into step.

Mr. Swinburne suggested, as a satisfactory test of parallel working, that the machines should be capable of being kept on full load without undue heating of the armatures. Referring to the word "synchronising," he thought its use in the paper rather ambiguous, for in some cases it related to "speed," and in others to "phase." As regards the efficiency of transformers working at different frequencies, he thought the comparison ought to be made on different transformers, each designed for the frequency under which it was tested. Under these conditions, and with 50-light transformers, increasing the frequency from 42 to 83 raises the efficiency from 92 to 93 per cent. when worked at full load all day, and from 60 to 62 per cent. when working at full load for two hours out of the 24. From some recent calculations he found the loss from eddy currents in direct-current armatures to be unimportant when thin plates were used.

Prof. S. P. Thompson, speaking of arc lamps, announced that he had recently localised the back E.M.F. in direct-current lamps, and found a sudden change in potential of 39 volts at the crater. He questioned Mr. Kapp's statement about the field-magnets increasing the self-induction of the armature, for the time was too small (about $\frac{1}{200}$ second) to allow such masses of iron to change their magnetism in obedience to the armature current. Prof. Thompson also gave a graphical construction for showing the distribution of work between two machines of different voltage when switched in parallel.

Prof. Ayrton, having obtained measurements of the self-induction of Mordey armatures by the secohmmeter, was in a position to say that neither Mr. Kapp or Dr. Thompson were quite correct, for the coefficient was 0·038 in position A (*see* Fig. 5) and 0·036 in position B; and both decreased about 14 per cent. when the magnets were fully excited. The frequency of the testing currents was about 100 in all the tests. From experiments recently made at the Central Institution on the efficiency of the Mordey transformer, with frequencies varying from 53 to 240, he said there is no evidence of greater efficiency for medium frequency; on the contrary, the efficiency increases with the frequency, particularly for small loads, and is nearly the same for all frequencies at the maximum working load.

Prof. Forbes thought the fact of the engines driving the alternators when the experiments were made being ungoverned, should be clearly stated in the paper, for this helped considerably to explain the phenomena. He also believed Mr. Mordey was perpetuating an error if he assumed that only two methods of distribution were possible—either separate large machines, or small ones in parallel; but it was quite common in America to divide the mains, and connect them to separate machines, when necessary, and the circuits are so arranged that two or more may be switched on one machine during the hours of minimum demand.

The **President** (Sir W. Thomson) suggested the expression "cophasedly synchronised," as meaning that the machines were in step both as regards phase and speed. To explain the result of coupling two alternators at 1,000 and 2,000 volts respectively, he considered the current resolved into two components, differing by a quarter of a period, and having their respective maxima at the position A and B in the above figure. The latter component would tend to magnetise the motor-fields and to demagnetise those of the generator, and in this way produce the observed phenomenon. Referring to the single-coil alternator, he thought it a beautifully simple and ingenious machine, and though some loss would arise from magnetic friction, this need not be great.

Mr. Raworth, who during the week had made experiments on the E.M.F. curves of alternators and transformers, exhibited a diagram showing the arrangement adopted. The results, though incomplete, were, he said, astonishing, and he thought the question of lag would be settled in a manner not in accordance with theory.

Mr. Mordey, in reply, said Dr. Hopkinson's difficulty arising from the loss in leads was not a serious one, for the high potential used in transformer systems rendered any considerable loss unnecessary. Referring to Prof. Adams's criticisms, he said he had laid no claim to the invention of parallel working, but had shown it to be perfectly practicable at a time when, in spite of the success obtained by Prof. Adams (to which he had drawn attention in his paper), considerable doubt existed as to its commercial possibility. He considered Dr. Fleming's explanation of the minimum generation of heat for mean periodicity a very probable one, and mentioned that, although the heating at periodicity 125 was more than that at 100, yet the current passing through the transformer was less in the first case. As regards Mr. Kapp's difficulty, Mr. Mordey admitted that a change of 500 volts did occur, and although he had not attempted to explain the matter, yet the straight characteristic given by the machine as a generator was a sufficient proof that as a motor the self-induction could not be great. Speaking of Mr. Swinburne's calculations on the loss due to eddy currents, he thought experiment far more satisfactory, and his observations showed the loss to be considerable. In reply to Prof. Ayrton, he said the method of determining the waste in transformers by direct currents was quite safe to use with efficient converters. From Prof. Forbes's remarks, he thought his views on parallel working had been misunderstood, for he did not recommend it under all circumstances, but in cases where all the prime motors and alternators would work without requiring a large margin, it is a great convenience to arrange the leads and mains so that they may be connected in parallel.

CITY NOTES.

Electric Construction Corporation, Limited.—Letters of allotment and regret in this Company have been posted.

Brazilian Submarine Telegraph Company, Limited.—This Company's receipts, for the week ended June 7, amounted to £4,689.

Great Northern Telegraph Company.—This Company's receipts for May were £22,800, making, from January 1, a total of £106,800, against £108,400 and £103,520.

Western and Brazilian Telegraph Company, Limited.—The receipts for the week ended June 7, after deducting the fifth of the

* *Journal*, vol. xvii., pp. 215, 216.

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gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,230.

Lancashire and Cheshire Telephonic Exchange.—The eighth ordinary general meeting of the shareholders of the Lancashire and Cheshire Telephonic Exchange Company, Limited, was held in Manchester on Tuesday, when a dividend at the rate of 8½ per cent. per annum was declared. The Chairman, referring to the proposed amalgamation of the Company with the United Company, deprecated the opposition of the Postmaster-General, and maintained that the amalgamation would be advantageous to the public.

Companies of the Month.—The following electrical companies have been registered during the past month:

Crompton Howell Electrical Storage, £1 shares	£19,600
Electric Tramcar Syndicate, £10 shares	20,000
Electric Construction Corporation, £10 shares	500,000
Halifax and Bermudas Cable Company, £5 shares	50,000
Jensen Electric Manufacturing Company, £5 shares	80,000
Keswick Electric Light Company, £1 shares	5,000
Liverpool Central Hydro-Electric and Massage Company, £1 shares	500
Medical Battery Company, £5 shares	100,000
Pontypridd Electric Lighting Company, £5 shares	10,000
Portsmouth and South Hants Electricity Supply, £5 shares	50,000

NEW COMPANIES REGISTERED.

Municipal Electric Light and Power Corporation, Limited. Registered by W. Webb and Co., 6, Essex-street, Strand, W.C., with a capital of £25,000, in 2,490 shares of £10 each, and 100 founders' shares of £1 each. Objects: to generate, produce, supply, and use in any manner electric or magnetic currents for the purpose of providing light, heat, motive power, etc. The first subscribers are:

	Shares.
F. White, 30, Crewys-road, Peckham	1
W. Grey, 11, Tissington-street, E.C.	1
E. Day, 22, Canonbury-road, N.	1
F. Julian, 36, Powell-road, Clapton	1
M. Sleet, 75, Shrubland-road, Dalston	1
E. Laming, 53, Lewisham-road, S.E.	1

There shall not be less than three nor more than seven Directors. Qualification, 25 shares of £10 each. The first to be appointed by the subscribers to the memorandum of association. Remuneration to be determined in general meeting.

PROVISIONAL PATENTS, 1889.

JUNE 3.

9153. **An improved dry galvanic battery.** Don Juan Arnold and Harlan Brant Coryell, 52, Chancery-lane, London. (Complete specification.)

9162. **Improvements in the armatures of dynamo machines.** Charles Eugene Lancelot Brown, 46, Lincoln's-inn-fields, London.

9163. **Improvements in electricity meters, or apparatus for measuring electricity, partly applicable for other purposes.** Leslie Bradley Miller, 46, Lincoln's-inn-fields, London.

9166. **An improved electrical repeater and commutator to indicate the normal position and the movements of railway or other signals, slots, and the like.** David Wells, 14, Brunton-place, Edinburgh.

9182. **Improvements in apparatus or devices for switching or diverting electric currents, more especially intended for use with telephonic circuits.** Alfred Graham, 47, Lincoln's-inn-fields, London.

9183. **An improved exciting liquid for electric batteries.** Max Sussman, 45, Southampton-buildings, London.

9185. **Electric safety signalling devices for railways.** Josef Haas, 115, Cannon-street, London.

9192. **A new or improved fitting for electroliers.** William Winstanley Strode and William Davis, 70, Chancery-lane, London. (Complete specification.)

9197. **Improvements in and relating to relays for telegraphic purposes.** Hugo Lubliner, 45, Southampton-buildings, London.

JUNE 4.

9231. **Improvements in the method of and devices for regulating currents generated by shunt wound dynamo-electric machines.** William Edwin Heys, 70, Market-street, Manchester. (Ernest P. Clark, United States.) (Complete specification.)

9237. **Improvements in dynamo electric generators and motors.** George Edensor Dorman, The Hawthorns, Stafford, Staffordshire.

9241. **Electric meters.** Alan Archibald Campbell Swinton, 66, Victoria-street, London.

9258. **Improvements in electric signal lamps and appliances connected therewith.** Frederick Lawrence Rawson and William Stepney Rawson, 11, Queen Victoria-street, London.

9284. **Improvements in metallic telephone circuits.** Henry Lyman Burbank, 53, Chancery-lane, London.

9294. **Improvements in and relating to dynamo-electric machines and electric motors.** Henry Harris Lake, 45, Southampton-buildings, London. (Charles S. Bradley, United States.)

9300. **Improvements in and relating to dynamo-electric machines.** Henry Harris Lake, 45, Southampton-buildings, London. (Hermann Lemp, United States.) (Complete specification.)

9304. **Improvements in switches for electrical purposes.** Wm. Barnicoat, 17 and 18, Southampton-buildings, London.

JUNE 5.

9350. **Improvements in dynamo-electric machinery.** John Johnson and Frederick Russell, 68, Gaisford-street.

9352. **Improvements in electrical horology.** Fernand Espir, agent for Paul Klotz, 3, East India-avenue, London, (Ludovic Belzon fils, France.)

9376 **Improvements in miners' electric lamps.** Henry Inkson Harris, 21, Cockspur-street, London. (Complete specification.)

JUNE 7.

9440. **Improvements in ceiling roses for suspending electric lamps and other electrical purposes.** Edward William Johnstone Macdonald, Bow Electric Works, Arnold-road, Bow. (Complete specification.)

9445. **Lightning arresters for electric conductors.** James Waring Sec, 52, Chancery-lane, London.

9456. **Improved method for preventing fumes from secondary batteries.** Bernard Mervyn Drake and John Marshall Gorham, 2, Princes-mansions, Victoria-street.

9461. **Improved composite electric omnibus.** Daniel McIntosh Reid, 41, Lamont-road, Chelsea, London.

JUNE 8.

9509. **Improvements connected with electrically operated coal mining and drilling machines.** Elmer Ambrose Sperry, 1, Quality-court, Chancery-lane. (Complete specification.)

9528. **An improvement in telephony.** Henry Coles, 15, River-street, Myddelton-square.

9537. **Improvements in incandescent electric lamps.** Illius Augustus Timmis, 2, Great George-street, Westminster.

9541. **Improvements in appliances for attaching telegraph and other wires to insulators and similar uses.** Frederick Lindley, 3, Poet's-corner, Westminster.

9552. **Improvements in electric meters.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

9571. **Arrangement of circuits and apparatus to be used in connection with telephonic communication.** John Edward Kingsbury, 24, Southampton-buildings, London. (Francis Raymond Welles, Belgium.)

9576. **Improvements in and relating to incandescent electric lamps.** Henry Harris Lake, 45, Southampton-buildings, London. (Silvanus Frederick Van Choate, United States.) (Complete specification.)

SPECIFICATIONS PUBLISHED

1888.

7237. **Miners' safety lamps.** Patterson. 8d.

9032. **Electric arc lamps.** Mortimer and Holloway. 8d.

10048. **Switching accumulators.** Drake and Gorham. 8d.

18220. **Electricity meters.** Batault. 8d.

19061. **Galvanic batteries.** Cornwell. 6d.

1889.

5142. **Electrical distribution.** Currie. 8d.

5621. **Electric-induction coils.** Lake (Thomson.) 8d.

5913. **Electric railways.** Van Depoele. 8d.

6112. **Secondary batteries.** Newton (Main.) 8d.

6119. **Thermo-electric batteries.** Shedlock and Mestern. 8d.

6423. **Electrical motors.** Jarman. 8d.

6527. **Electro-motors.** Lake (Tesla.) 8d.

6547. **Circuit controllers for electric currents.** Currie. 8d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	4½
12 Feb.	2/0	— fully paid	5	4
14 Nov.	0/4½	Con Telephone & Main	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	19½
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	½
......	...	London Electric Supply	5	3¾
......	...	Swan United	3½	3¼
12 July	12/0	Telegraph Construction	12	42½
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15½

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NOTES.

Prof. Houston.—We understand that Prof. Houston has gone over to Paris, but will return to London later on.

Deptford.—A number of the American engineers now on a visit to this country and to the Paris Exhibition, were shown over the Electric Lighting Works at Deptford on Wednesday.

Blackpool Electric Tram.—On Whit Monday, the number of passengers carried on the Blackpool Electric Tramway was over 11,000, and the receipts exceeded £87, and recollect this was without cruelty to horseflesh.

Glass Insulation.—The method of laying underground wires by placing them in glass tubes protected by a layer of cement, and surrounding the whole with an iron pipe, is said to give a high degree of insulation, and to be watertight. It seems to us, however, to possess several palpable drawbacks.

Electric Sugar Fraud.—Mr. Howard, one of the persons alleged to be implicated in the electric sugar swindle, has been found guilty of "grand larcency" by the jury, and sentence will be pronounced in due course. Such is the New York telegram. Would that some of the men on this side also had their deserts.

Royal Military Tournament.—All the badges used at the above tournament by H.R.H. the Prince of Wales, H.R.H. the Duke of Cambridge, and all the officers and gentlemen composing the various committee, also judges, staff, and competitors, have been made by the Endolithic Ivory Company, Pomona-buildings, Fore-street, E.C.

Derby.—The central installation of Messrs. John Davis and Son seems to bid fair for success. The boiler for this installation has been supplied by a local firm, Messrs. Walley and Sons, the engine by Messrs. Marshall and Sons, and the dynamo by Holmes and Co. As the current to the lamps is from accumulators it is always available.

Felten and Guilleaume.—Referring to our paragraph *re* Mulheim cables, we are informed that Messrs. Felten and Guilleaume are manufacturing a sample half-mile of Ferranti cable for the company with which Mr. Ferranti is connected, and which is similar in construction to the short samples already submitted, and which gave excellent results.

Electric Hoist.—Messrs. Drake and Gorham are paying considerable attention to the application of electricity for motive power in private houses and offices, and have been very successful in their application of electricity to working electric lifts for banks, etc. Those which they put down last year are all working successfully, and the cost of maintenance is found to be extremely low. We are informed they have now received instructions to fit up a somewhat larger lift for the Bank of England, which is to be ready for use in the course of the next month.

Company Promotion or Progress.—We have received from the Secretary of Elmore's Patent Copper Depositing Company, Limited, a criticism on our statement on this subject in our last week's issue. The writer says that the Copper Depositing Company was formed about four months ago, and will soon be in a position to demonstrate from its actual output the value of the process. He also informs us that our figures at the close of the paragraph are incorrect, and refers us to Messrs. Woodhouse and Rawson to be put right, yet our figures were those supplied by the writer himself.

Electro-Plating.—*Ironmongery* says: "There is in many branches of the hardware trades of the Midlands a splendid field for enterprise on the part of makers of electro-plating apparatus. Day by day the process of electro-plating is entering more largely in the hardware branches, in which a high degree of finish is desirable. If an apparatus of simple description, and moderate in price, for occasional use only, were brought under the notice of the hundreds of small manufacturers who abound in this district, no doubt a large trade would be done, as having electro-plating 'done out' is too costly an experiment to be very largely adopted."

St. Martin's-in-the-Fields.—Messrs. Gatti have sent a letter to the Vestry stating that they are able to supply electricity in the district to the extent of 8,000 lamps of 16 c.p., and can extend it shortly to 30,000 lamps. Mr. Laing said that he and Mr. Prescott, together with the surveyor, attended before the Board of Trade and opposed the idea of any one company having a monopoly, which Mr. Courtenay Boyle endorsed. He would move that Messrs. Gatti have the same facilities as the two companies. Mr. Prescott seconded the motion, which was supported by Captain Probyn, who said that Messrs. Gatti were able to supply 7,000 lamps. The motion was carried.

Specimens of Wire.—We have received from the Telegraph Manufacturing Company an exceedingly neat and handy case of their wire. Some 50 or 60 samples are contained in the case, and the samples, being on cards, can be easily taken out and replaced by new ones. Of course, there is much more to be thought of when purchasing covered wire than can be shown in samples, though after experience with the make, orders might be freely given after inspecting such samples. However, the production of such a case as this shows that the company is endeavouring to provide for the wants of customers, and are pushing forward for business.

Royal Society.—The June conversazione was held on Wednesday last. At this reception it is well known that ladies are present, and this adds to the gaiety, and probably brings the evening more in accordance with what a conversazione is generally understood to be. Among the various exhibits, we may mention that Colonel Gouraud was to the fore with Edison's phonograph. Prof. Silvanus Thompson exhibited his acoustic apparatus, illustrating polarisation of light, while Messrs. Mond and Langer showed a new form of gas battery, said to be an improvement on that of Grove. The assembly numbered some seven or eight hundred, and included almost all the best-known names connected with science.

Another New Company.—The transference of the well-known electric machinery, lamp, and apparatus manufactory of Mr. S. Schuckert, Nuremberg, to a company under the title of Schuckert and Co., Commandit-Gesellschaft, as we learn from a circular sent out, was accomplished on the first of April. In addition to the Nuremberg business and its branches at Leipsic, Cologne, and Breslau, the Münchener Commandit-Gesellschaft fü elektrische Beleuchtung und Kraftübertragung S. Schuckert and Cons. has also been taken over by the new company. The members of the late firm, Mr. S. Schuckert and Mr. Alexander Wacker, will devote their personal attention to the new company.

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Gillingham.—At the last meeting of the Local Board, a letter was read from the local electric light company stating that as the Board of Trade had intimated that statutory powers should be obtained for placing mains underground instead of overhead, the company begged to inform the Board that application was intended to be made on or before December 21 next, by memorial to the Board of Trade, for a provisional order to be confirmed in Parliament in the ensuing session, whereby it was proposed to authorise the company to apply electricity for any private or public purposes within the district of the Gillingham Local Board. Mr. Mackey supposed the Board would not offer any opposition to the application. The chairman replied that there was no intention of proceeding with any formal proposition.

St. James.—A letter from the Metropolitan Electric Supply Company was read to the Vestry, stating that they are gratified at the position that the Vestry has taken on their behalf, and adding that should they be so fortunate as to obtain a provisional order for this district, they will always do their best to meet the wishes of the Vestry in every way in their power; also one from their solicitors, stating that the company will use every means in their power to induce the Board of Trade to include this parish in their district, and that they believe they can supply electricity on well tried and established principles effectively to the parish from stations which the company have acquired in reliance on the parish having been granted to them by the Board of Trade last year, and the support of the local authority.

London County Council.—At the last meeting of the Council, the chairman stated that a letter had been received from the Board of Trade thanking the Council for the assistance it had given in the matter of electric lighting, and sending a copy of a model order proposed to be followed in the case of all the electric lighting applications now before the Board of Trade. This letter will be reported by the Highways Committee probably at the next meeting of the Council. In the meantime the Board of Trade stated that if the Council wished to bring any points in the order under the notice of the Board, the Board would be glad to see representatives of the Council, and to discuss such points with them. Perhaps the Council would authorise the Highways Committee if it should think necessary to depute to representatives to confer with the Board of Trade, and to suggest, on behalf of the Council, any alterations they might think desirable.

Inspection.—Mr. Land, in our American contemporary, *The Electrical World*, makes a suggestion which also meets with editorial approval in that paper. The author of the suggestion has visited several hundreds of lighting stations in the smaller towns, and has noted many imperfections which exist, and he suggests the imperative need of a competent general inspector. He thinks that the cost of such inspection should be borne by the various companies, and that the inspection would lead to improved service, and thus to greater economy. From a cursory examination of this question, we doubt altogether its feasibility. It seems to us that the weak point is not after the installation is started, but when the installation is being designed and before it is commenced. The superintendence wants to be close during the carrying out of the installation, to see that the workmen do their work properly and to see that the design is faithfully followed; but there may be something to be said for such a system, although we cannot at present see it, hence we refer to the suggestion for what it is worth.

Electric Lighting on the "Exmouth."—A report upon the subject of the electric lighting of the training ship "Exmouth," the vessel which took the place of the ill-fated "Goliath," destroyed by fire some years ago, was read at the last meeting of the Whitechapel Board of Guardians. The managers, the report stated, were anxious to secure the best form of lighting, not only as regards economy, but also as regards safety. Three years had elapsed since the electric lighting of the ship had been completed, and the managers had come to the conclusion that the approximate annual cost of such system was £665, while the annual average cost of lighting the ship by means of colza oil during a similar period was £680. A positive saving had thus been effected, besides obtaining a greater security from fire, together with other advantages, including the greater cleanliness and extended opportunity of training the boys in all parts of the ship, irrespective of atmospheric conditions, so that the actual cost of the electric light could only be regarded as approximate.

Lucerne.—The public electric light installation at Lucerne, says *Industries*, was inaugurated on the 25th ult. The town had already a central station for the supply of electricity to private customers, and now a very fine display of arc lamps, for the illumination of the quay and principal streets, has been added. The financial part of the work was undertaken by a private company, and the technical part was carried out by Messrs. Troller Brothers, who were the first to introduce electric power and light plant in Lucerne. For the street lighting there are provided twenty-two arc lamps, fixed on ornamental iron posts, and the town pays the company for the light supplied at the rate of £16 per lamp per annum.—In response to an invitation from the town authorities of Zürich for tenders for a central electric light station, nine tenders have been received, of which five are from Swiss and four from foreign contractors. Amongst the Swiss firms who tendered are the Zürich Telephone Company and the Oerlikon Works, and amongst the foreign firms are Messrs. Siemens and Halske and Messrs. Crompton and Co.

The Military Tournament.—Electricity plays its part in the entertainment which is now annually held at the Royal Agricultural Hall under the title of the Royal Military Tournament. A full dress rehearsal of the tournament was held on Wednesday when a realistic scene was rehearsed The southern end of the hall has been prepared, and presents a place of arms with its outworks. Across the hall, from north to east, is laid a river, with its banks. A cyclist corps comes as skirmishers, and signal the general advance. All is done with realistic force, and in due order a division advances to the attack of the fortified position, the division including infantry, a Bianconi car, a Maxim gun on field carriage, a horse artillery gun, a Hotchkiss revolving cannon, in the hands of the Field Artillery, who are considerate enough not to fire it even with blank cartridge, a Royal Engineers' bridging battalion, and medical staff, these formed of the useful Volunteer Medical Staff Corps. The Royal Engineers build a bridge with all celerity. The bridge built, the attack commences, and the enemy brings out the Hotchkiss gun, mounted on an armour-plated electric wagon. The work on both sides is well sustained.

Leeds.—A meeting of the Electric Lighting Committee of the Corporation, Mr. L. Hardwick presiding, was held recently to consider the report of Mr. Hewson, the borough

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engineer, in reference to electric lighting in Leeds. The report was considered at great length, and it was agreed to adopt the recommendations it contained in reference to the lighting by electricity of the Council Chamber, the Courts of Justice, and the offices in the Town Hall and the Municipal Buildings. The proposal as to the establishment of a central electric station upon the "Midden" was deferred to a future meeting. As a result of the committee's action, the arc lamps in the Victoria Hall will be removed—assuming, of course, that the Council offer no objection—and will be replaced by incandescent electroliers. It is proposed that the arc lamps shall be fixed in the streets surrounding the Town Hall. It is estimated that over 2,000 lamps will be required to illuminate the Town Hall and Municipal Buildings, and that the scheme will cost £3,000. It is also proposed to ask the Corporation to apply for a provisional order to supply electric light generally. The estimated expenditure under the order is £68,000.

Taunton.—Mr. B. A. Wood writes the following letter to the *Somerset Express.* We give the letter as showing, not perhaps literary excellence, but that the electric light is appreciated, and, once adopted and fairly installed, those who use it once urge its extension. "The wonders of the electric lamp excel the anticipations of its most sanguine friends. The brilliancy and steady flow of its light leaves the glimmering and fitful flame of the old-fashioned gas-post far behind. The universal adoption of this beautiful, efficacious, and safe method of illumination cannot be far off. Science has, indeed, perfected at last one of the most useful discoveries, tending to the comfort and enjoyment of life, in these wonderful times. Darkness is abhorrent to nature; vegetable and animal existence—alike sleep it away. The modest daisy folds up her bosom within her protecting nightcap and retires to rest, joyfully welcoming the return of light. The lark 'from his moist cabinet' greets the return of morning, but man has now created for himself universal day and will forget his hour of rest, while 'nature's sweet restorer' will be less than ever necessary to his enchanted existence. Let us hope that the presiding genii of this 'wonderful lamp' 'at whose bright presence darkness flies away' will extend his radiant influence to some of the side streets."

Light and Power.—The *Transactions* of the Chesterfield and Midland Counties Institution of Engineers just issued, contains a paper by Mr. Winstanley Wallis dealing with electric lighting and transmission of power in mining. The author gives a list of English collieries at the present time using electric light. The total number is 42, and of these 6 are in Derbyshire, 3 in Durham, 3 in the Manchester district, 3 in Northumberland, 1 in the North Wales district, 20 in South Wales, 7 in Staffordshire, 3 in the Wigan district. There does not seem to be many installations for the transmission of power. The author refers to the well-known ones at Trafalgar Collieries in the Forest of Dean, and at St. John's Colliery, Normanton, so far as England is concerned. We are glad to see that the author objects to the cry of "Wait for further improvement." The electric light at the present moment is far better than any other, and there is little margin for improvement in the small installations such as are used in colliery work. One paragraph we may quote here: "It should be noted, said Mr. Wallis, that collieries possessing an electric light plant are in a position to adopt electric safety lamps at a small outlay, referring, of course, to lamps using storage batteries, such as the Edison-Swan, Pitkin, and others, as it is not probable that lamps with primary batteries will be extensively used till zinc costs as little weight for weight as coal."

School of Electrical Engineering.—Examinations for the certificate of this school have recently been conducted by Mr. Gisbert Kapp, A.I.C.E., and Mr. Kempe, of the Engineer-in-Chief's Office, General Post Office. For the certificate in electric lighting and power transmission, Mr. Kapp set a paper in mechanical and another in electrical engineering, and he devoted many hours to practical and *viva voce* examination of the students on (to quote his report to the managers) "steam-boilers, arc lamps, calibrating, resistance-measurements, jointing, photometry, switches and management of circuits, and practical use of graphic methods as applied to dynamos." A minimum average of 70 per cent. of full marks in the practical work, and of 60 per cent. in each of the two papers is a necessary condition of obtaining the certificate. Of eleven students at the practical examination, only three failed to exceed this minimum. Certificates in electric lighting and power have accordingly been awarded on Mr. Kapp's report to the following gentlemen: Messrs. Wm. J. Alexander, G. Horley, T. Raaschon, F. Wallis. Mr. H. R. Kempe set two papers, one upon electrical testing generally, and the second containing special and practical questions upon telegraphy and telephony, in which a minimum of 70 per cent. of full marks was required. As the result of his report, certificates in these subjects have been awarded to Messrs. W. St. J. Beale, H. C. Moberley, and H. H. Paynter.

Royal Agricultural Society.—The Jubilee Exhibition of the Royal Agricultural Society opens to-morrow in Windsor Great Park. A glance through the catalogue shows that there are a great many exhibits which should be interesting to electric light engineers, principally connected with engine-building. We may point out, however, that the electric light engineer often has to erect temporary buildings quickly, and perhaps an investigation of the yard at Windsor would show many different ways of doing this. With regard to the engines, we notice that at Messrs. Robey and Co.'s stands, Nos. 1 and 361, that out of the 16 items in this firm's exhibits, nine of them relate to engines, while Messrs. John Fowler and Co., at No. 4, show seven of their engines. Stand 58, is that of Messrs. Dennis and Co., the well-known agents for Messrs. Felten and Guilleaume, who exhibit wire, etc. Stand 64 is that of Messrs. Willcox and Co., who exhibit belting of various kinds, engine-packing, lubricating oils, and engineers' sundries. At stand 74 Messrs. Immisch and Co. show an electric carriage. Stand 275 is that of Messrs. Ransomes, Sims, and Jefferies, who have a very large exhibit, amongst which will be found seven of their well-known make of engines. At stand 316 Messrs. Ruston, Proctor, and Co. exhibit engines of various kinds—portable, horizontal, semi-fixed, and vertical. At stand 371 the British Gas-Engine Company show a number of their gas-engines, which engines are becoming more and more popular, and especially so since the trials before the Society of Arts. Advertisements referring to the manufactures of these various firms will be generally found in our advertisement pages.

Electrical Census Machine.—This system of machines may be described as follows: The census collector will call with his printed blank, and answers to questions will be written in the usual way. These sheets will then

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be placed before a person who operates a machine which may be likened to a type-writer, except, instead of the usual ink mark on paper, small round holes are punched in a card. The cards, one for each person, are about 6½ inches in length by 3 inches in width, and the particular position of a hole in a card indicates an answer to some of the questions in the printed blank. As many as 250 items of information can be punched out upon a card, although no one card would ever have more than one-tenth part of the whole number, as, for example, no one person can be classed as both white and black, American and foreign born, and if foreign born he can only come from one country. These cards when punched are placed one at a time in a sort of press, and a lever operated by one hand is brought down, when a series of pins are brought against the card. Whenever a hole has been punched in a card the corresponding pin passes through into a mercury cup beneath, completing an electric circuit. These circuits, one for every hole, pass out to a large number of counters which operate electrically, and which add upon their dials all items of the same kind upon the same dials; as, for instance, all white men upon a dial marked white males; all business or professional people upon dials which indicate their particular business or professions. The cards, as they leave the press, are all sorted by means of an electrical sorting device, whereby they may be separated into groups or States of the Union. It will thus be seen that the machines are much more reliable than the most accurate human agency, and that one machine will do the work of a large number of clerks. The next census of this country will be taken with these machines, and two will be sent to New York soon for the 1890 census taking.—*Scientific American.*

Electrical Launches.—A new electrical launch, called the "Pioneer," has been especially designed and built for Mr. Andrew Pears by W. Sargeant and Co., launchbuilders and electrical engineers. The vessel was launched on Saturday, the 15th inst., before a large and enthusiastic audience, from the builders' works, Strand-on-the-Green, Chiswick. The boat is 40ft. long, with 5ft. 8in. beam, and designed to carry about 20 passengers, with a mean draft of 18in. The boat has a displacement of 5¼ tons. The speed is about seven miles an hour. The electrical apparatus is placed below the seats fore and aft, leaving a clear run the whole length of the launch. In the centre is a handsomely fitted cabin executed in bright teak, as are all the other fittings throughout. The hull is constructed of three skins, the inner being diagonal, with outside planking of bright mahogany in narrow widths. Deadwood aft has been entirely abandoned with the object of assisting the steering in narrow water, besides giving a clear run and obtaining greater efficiency from the propeller. The rudder, on an entirely new principle, is cast in Delta metal, with the object of clearing weeds, obviating sternpost, deadwood, and gudgeons, with facilities for quick removal and easy steering. The steering wheel is situated in the front part of the cabin, on the port side. The lead-lined compartments are arranged to receive sixty E.P.S. accumulators, 1889 type, placed in ebonite boxes. The midships section of this craft being perfectly flat, in the event of her taking the ground the acid will not slop over; and the construction is similar to the "Viscountess Bury," 65ft. by 10ft., also built and designed by W. Sargeant, which was launched in October. The motor is a 6in. Immisch machine, which is calculated to develop 6·0 maximum brake h.p., rotating at 1,400 revolutions per minute. Highest E.M.F. 200 volts, lowest 60 volts, half-speed 700, indicating about 3·5 b.h.p. The motor is placed under the floor aft and ventilated. All lights for port, starboard, masthead, and cabin will be incandescent electric lamps supplied direct from the accumulators; ammeter and voltmeter will be placed in front of the wheel and in sight or control of the steersman. All the machinery and power being placed under the seats and floor, leaves a clear space from stem to stern. The windows are of engraved plate glass, with teak folding doors leading into after-cabin, which is open on the port and starboard side. The "Pioneer" will be at Henley Regatta.

Woodhouse and Rawson.—This firm is appointed to the sole agency for the sale of a book, entitled "The Electric Railway," by Fred. H. Whipple, of Detroit. With this notification we have also received a small catalogue of Mr. Whipple's, which has a couple of pages devoted to suggestions, in the following strain: "If you are thinking of purchasing electric light machinery, always take advice from an electrical engineer as to what is best adapted to your needs. A great many plants are put in that do not give satisfaction, because they are of the wrong kind, or are too small. A person writes to a company that he wants a plant of a certain size, and the company puts it in, supposing that he knows what he needs. He, perhaps, finds that it does not suit him, that it ought to be arc light instead of incandescent or *vice versâ*, or that it is too small, and he condemns electric light as a consequence. Sometimes it is the agent who does it. How much better to go to a competent man, one who has experience and judgment, and who can advise as to what is needed, and save trouble. The construction work is as important as the machinery, and should be planned properly. If a man builds a house he generally consults an architect. If he is putting in an electric light plant why not consult an engineer? The difference between the various makes of electric machinery is similar to the difference between different makes of engines, in details and points of excellence and not in principle, and 'companies' are only manufacturers of machinery. Whatever you do, do not buy cheap electric light machinery. With some kinds of machinery it is impossible to get results which will do, even if cheap and inferior; but to get what is wanted—a good and economical light—it is necessary that the machinery be perfect, and therefore somewhat expensive. Do not buy machinery which is experimental, but take only that which has an established reputation. If you wish an estimate, send a sketch of your town, showing your opinion of the location of the lamps. Show the location of the proposed station, and state the kind of power you have, or whether power is to be put in also. If it is incandescent lighting, say whether the buildings are wood, stone, brick, or iron, and wet or dry, and also whether the wiring is to be surface-wiring or concealed. Competent engineers sent to any locality on a moment's notice. Plans and specifications prepared, and plants laid out in a first-class manner. If you want cheap work, do not invite us. We advise nothing but the best."

Edinburgh.—In connection with an exhibition of electrical engineering and mechanical inventions which is proposed to be held in Edinburgh, in the spring of next year, to commemorate the opening of the Forth Bridge, a deputation waited on Lord Provost Boyd in the City Chambers on June 13th at noon. The deputation consisted of Principal

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F. Grant Ogilvie, Heriot-Watt College; Mr. A. R. Bennett, general manager for Scotland of the National Telephone Company; Mr. David Allan Stevenson, C.E.; Mr. G. W. W. Barclay, Mr. Mitchell Thomson, Mr. John Harrison, and Mr. George E. Watson, C.A., interim secretary. Treasurer Clapperton introduced the deputation to his Lordship, who was accompanied by Bailie Walcot. Mr. Bennet made a statement regarding the scope of the exhibition, for which the patronage and support of the magistrates and Town Council were desired. After some remarks by other members of the deputation, the Lord Provost expressed his willingness to give the matter his most favourable consideration. A large and influential committee has been formed for the promotion of the exhibition, including Professors Tait, Armstrong, Chrystal, and Crum Brown, the Lord Justice-Clerk (who is to be an exhibitor), Mr. W. H. Preece, Chief Electrician G.P.O., Sir Thomas Clark, Mr. J. R. Findlay, Mr. Robert Cox of Georgie, Mr. W. B. Blaikie, and some of the principal engineers and officials connected with the Forth Bridge. It may be mentioned that the exhibition is proposed to be held in a field at Meggat Land, in the neighbourhood of Merchiston, which is very easy of access by tram and rail; and, that should the exhibition be proceeded with, it is not unlikely that the convention of telephonic and electrical engineers might be held in the city at the same time. The following reasons are given for holding such an exhibition: (1) The completion of the Forth Bridge, which is likely to bring to Edinburgh a considerable influx of people specially interested in the branches and knowledge which the suggested exhibition is primarily intended to illustrate. (2) There never has been an exhibition of electrical engineering in Scotland before. (3) The combination of mechanical inventions, with electrical engineering, is likely to open an interesting field to all visitors. (4) There is no topic which is exciting wider interest than practical electricity, capitalists, small investors, men of science, and young men choosing a profession, are all looking towards it as a chief factor in business life. It is daily becoming more and more a convenient agent, even in household affairs, so that everyone is eager to form acquaintance with the many recent electrical inventions. (5) The space for the comparatively small electrical exhibition to be held this year in the Bingley Hall, Birmingham, has already been greatly over applied for.

The Telephone Controversy.—The following letter has been sent by the United Telephone Company in answer to that of Sir A. Blackwood, given in our issue of June 7, page 463: "Sir,—I am instructed by the directors of the United Telephone Company to acknowledge the receipt of your letter of the 4th inst. The directors are much surprised at the statement made by the Postmaster-General, that the amalgamation of the companies was not contemplated when the licenses were issued. It is impossible to suppose that the legal advisers of the Post Office were ignorant of the fact that it is competent for a company registered under the Joint Stock Companies' Acts to liquidate and sell its business to another company similarly registered. Such an arrangement is one of almost daily occurrence, and if there had been any intention or desire on the part of the Postmaster-General, when these licenses were granted, to interfere with such an arrangement, the obvious course would have been to have inserted a clause in the license restricting the company's ordinary rights in this respect. The directors desire respectfully, but firmly, to join issue with the Postmaster-General on the question of fact. Even if the license had been silent on the subject, it would have been impossible to suppose that the legal advisers of the Post Office had overlooked so obvious a point. But, as a matter of fact, the purchase by one company holding a license from the Postmaster-General of the telephone exchange business of another company holding a similar license was contemplated, and the license contains clauses (the precise wording of which was the subject of considerable discussion at the time) providing for the consequences which are to happen upon the sale by a company of the whole or of a part of its exchange business. One of these provisions (drawn by the solicitor of the Department, and inserted after the license was in type) requires that seven days' notice of any such sale shall be given to the Postmaster-General. How, under these circumstances, it can be said that the possibility of such a sale was not contemplated when the licenses were issued the directors are at a loss to understand. The Postmaster-General must surely have overlooked the fact that on three distinct occasions since the granting of these licenses, companies or persons holding licenses to carry on the telephone exchange business have transferred their exchanges to other companies holding similar licenses without the slightest objection being raised by the Postmaster-General. In all these cases the sale was by a competing company to a company working under the United Telephone Company's patents. In the present case (as the Postmaster-General is aware) there is and can be no competition between the companies uniting because, although each company has a license from the Postmaster-General, which entitles it to carry on the exchange business in any part of the United Kingdom, each company, by agreement with the others, works only in its own district. This fact was well known to the Department at the time the licenses were granted. The directors, therefore, fail to understand to what the Postmaster-General refers, when he speaks ot the state of things likely to result from the proposed amalgamation. The union will not affect the question of competition between the companies one way or the other, while it will undoubtedly lead to increased economy and efficiency in working. In objecting to the exercise by a joint stock company of its undoubted right to transfer its business to another company the Postmaster-General is seeking to impose upon the telephone companies the restrictions of a parliamentary company without any of its privileges. As the Postmaster-General is aware, the United Telephone Company has more than once applied to Parliament for incorporation upon the lines recommended by the Parliamentary Committee which investigated the matter and reported in the year 1885, but the Postmaster-General has consistently opposed these applications. The directors ventured to suggest that the interests of the public would be better served if the heavy tax imposed by the Department upon telephonic communication (a tax which is obviously really paid by the public in the shape of increased charges) were removed, and reasonable facilties were granted to the telephone companies, which would enable them to give to the public a cheaper and a better service. The directors have loyally carried out the engagements which they entered into with the Department when the terms of the present license were, after much consideration, settled by the late Mr. Fawcett, and they are unwilling to believe that the present Postmaster-General will attempt to reverse the policy of his predecessors or to withdraw from any assurances, honourable or legal, given by the Department."

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THE PARIS EXHIBITION.

I.—GENERAL REVIEW OF EXHIBITS.

The great Exposition Universelle at Paris is now open and in full swing in every department, and no one need hesitate any longer to cross the Channel from the fear of being too early to properly inspect what is to be seen. To the electrical engineer this Exhibition will be thoroughly interesting, not so much perhaps because of great surprises or new developments—though the Exhibition is not without important novelties in electrical work—but for the very thorough manner in which the possibilities of electric lighting have been taken advantage of, both for the complete lighting the whole of the buildings, and for the magnificence of the effect of the decorations and illuminations, as well as for the indications which are apparent of the progress of electrical engineering in all the heavier departments of applied science.

As already announced, our intention is to publish the description of the electrical exhibits at the Paris Exhibition in French and in English in parallel columns, a method which will make it interesting and useful alike to the Continental as well as to the English and American exhibitors, and will serve at the same time to enable these latter to better introduce and describe their goods to the French visitors at the Exhibition. A special edition of the journal will be sent to the Exhibition for distribution amongst the exhibitors and their clients, and copies will be obtainable without charge by those desiring them at the stalls of the principal English and American electrical exhibitors.

Before describing the machines and exhibits in detail, it will be well to give some general idea of the Exhibition and of the electrical section in its main features, for every visitor will at first wish to look round and to take the main bearings of the place before commencing a thorough inspection of the exhibits in which he is particularly interested. Our technical readers will excuse us while we mention in a few words the beauties of the Paris Centenary Fête. Of the arrangement of the Exhibition itself too much praise cannot be said. Beautifully designed and admirably carried out, the buildings are a marvel of beauty and of interest, everywhere the most elaborate finish, the most artistic *tout ensemble*, alike pleasing to the eye as provocative of wonder that so complete and artistic architectural and decorative work should be expended upon a temporary erection. Buildings, apparently fit almost to vie with St. Paul's in size, and with Italian churches in detail of façade, are surrounded with gardens laid out with all the skill of the best landscape gardeners, furnished with central electric lighting stations of thousands of horse-power capacity, which are completely fitted in separate buildings, having marble switchboards, glazed mechanical regulators, and a complete system of underground mains. Throughout the dozen separate buildings Arabs, Egyptians, Servians, and other nationalities mix with the French, English, and American visitors, and throng the gardens, around which at night the arc lamps in profusion glitter among the trees, and the Edison lamps in thick rows fringe the grass plots, and surround the buildings. The illuminations are arranged, not, as with ours, simply in straight lines, but in curves, twists, crescents, and studied artistic effects, for which the French always bear the palm. The luminous fountain at night, shot with lovely and variegated colours, draws rounds of applause from the assembled crowds, who watch its dancing rainbow spray or drops glittering in the beams of the subterranean arc lamps, while above, away up in the sky, a long flare of light stretches away from the lighthouse projector to the very outskirts of Paris from the summit of the Eiffel Tower.

The Eiffel Tower is, of course, the great feature of the Exhibition, and dominates the whole scene, and no notice of the Exhibition would be complete without mention of it. In the daytime one cranes one's neck to see the top of it, while the great arches yawn half across the whole Exhibition ground, and from the second landing even the green country can be seen round the city of Paris. At night the tower is ringed with light from rows of lamps outlining the immense arches, while above the long projector-flash slowly revolves.

At the other end of the grounds, stretching from side to side, is the immense Palace of Machines, the largest building under one roof in the world, and it is here that the exhibits interesting to electrical engineers will mostly be found. The building is so large that it dwarfs everything within it. Those little arc lamps away in the roof are, in reality, large Crompton lamps with globes some 3ft. diameter, and when standing on the ground the lamps can be seen to be a foot or two taller than the workman who is cleaning them. Very neat is the arrangement adopted by Messrs. Crompton for pulling these lamps up and down, as we shall see when we come to describe them in detail. The Palais des Machines is one vast span of 330ft. wide, 150ft. high, and 1,500ft. long; it is crowded in every part with machinery in motion or otherwise, and the engineer visitor might well spend a week in inspecting the exhibits in simply this one building.

Down the middle of this immense concourse of machinery, two wide lines of overhead rails stretch from one end to the other, one on each side of the central aisle. On these run the electric rolling bridge—le Pont Roulant—originally the movable crane to place the machinery, but now fitted with a platform and chairs for 50 or 100 persons, and used to carry passengers from one end of the machinery hall to the other. From these movable bridges the best general idea of the gallery can be obtained, and a ride on one of them—after one o'clock, when the steam is turned on and the machinery is in motion—gives a splendid panorama of the multudinous engines and active machines below. These electric travelling bridges are by Messrs. Megy, Echeverrin, et Bazan, of Paris; they are worked by an electric motor geared by bevel friction-wheels, and appear to be extremely efficient in action, and very easy to manipulate.

Just outside the Palais des Machines is the central electric light installation, for which the power is supplied by Messrs. Davey, Paxman, and Co. The same boilers supply the steam power for the machinery in motion in the Palais, and a large underground network of steam-pipes serves to distribute the steam. At one o'clock an immense vibrating whistle or boomer shakes the whole building with its note and the engines start into motion, machinery begins to revolve, and electric lights, arc and incandescent, begin to glow in every direction.

The British section is at the further end of the hall. We notice first Messrs. Crompton's stand, with three large Westinghouse engines driving the Crompton dynamos which supply the hanging lamps for lighting the whole of the British section. Twenty-four of these lamps are of 25 amperes and are run in one circuit in series. Other 79 lamps are of 8 amperes and are run three in series and the circuits in parallel. Just near, on one side, is a magnificent exhibit of electrical instruments, in a fine kiosk to itself, by Messrs. Elliott Bros., and of this exhibit the British Commissioners consider themselves proud, both from the beauty and finish of the workmanship and the completeness of the exhibit. Mr. Ilius A. Timmis shows in working order his simple and effective long-pull magnetic semaphore for railway lines, with repeating indicators for the signalmen, a method which is rapidly achieving great success, especially on new Colonial and South American lines. Messrs. Avery show Snelgrove's electric weighing-machine, an ingenious instrument in which the principle of automatic regulation by means of a double tipping contact energising a motor, is made to advance or retire a weight on a yard-arm, and at the same time setting in motion geared wheels marked with the weights to be read off, thus automatically registering the weight.

The Hermite system of electrical production of bleaching solution, by means of plates filled with platinum gauze electrodes, made by Messrs. Paterson and Cooper, and recently described by us, is shown in one corner. Messrs. Paterson and Cooper's own stand of electrical measuring instruments is close by; next to it, on one side, Messrs. Mayfield's large Wimshurst machine, and on the other, the Globe Electrical Company's mica cut-outs, with switches and fittings, and the Hedges' rotating liquid speed indicator. Messrs. Latimer Clark, Muirhead, and Co. have also a fine stand of instruments, resistances, etc.; and the Eastern Telegraph Company are to the fore with a mouse mill Morse recorder, to be seen in action. The Electrical

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Power Storage Company are showing the ingenious apparatus of switches and regulators for accumulator central systems, as adopted at Chelsea; while the India Rubber Company, of Silvertown, Messrs. Fowler, of Leeds, and Henley's Company show cases of samples of cable. It cannot be said that Britain is sufficiently represented to indicate its large share in the advancement of the practice of electrical engineering. The exhibits are certainly very good, but they are small, both in number and extent, as compared with the displays of the 290 exhibitors in the French section. This was to be expected to some extent, the Exhibition being, of course, a national enterprise, but we were sorry to hear that the Brush Company and other well-known firms had not thought it well, or were too busy with paying work, to represent England at the Paris Exhibition. All the more credit, then, to those firms who still show in finish of workmanship and arrangement of power or of lighting what position Britain takes in the electric progress of the world. One other firm well known in this country is well represented by means of its Paris house. We mean Ferranti. Just inside the Trocadero entrance across the river, and before one gets to the Eiffel Tower, is a central station in which the principal dynamo, of 12,000 watts capacity at 2,400 volts, is a Ferranti machine, made by Ferranti, Patin, et Cie., of Auteuil, near Paris, and this supplies a large circuit of both arc and incandescent lamps, extending a distance of some two kilometres.

To go back to the Palais des Machines, we come next to the American section. Here Edison is triumphant. Under Mr. Hammer's skilful arrangement, Edison makes a show which is the largest for any one person in the whole Exhibition, excepting, of course, M. Eiffel. His globe of incandescent lamps 40ft. high stands in the central of the Palais. It is composed of some 20,000 lamps disposed in the form of a large Edison lamp, and will be flashed at intervals at night. An immense Edison dynamo dominates his stand, the largest double-pole dynamo in the Exhibition, while near beside it stands one of the smallest practical dynamos, like Chang and the dwarf. The municipal three-wire system is represented by exhibits of cables and conduits, and by plans of the New York central station, and the illustration of the Edison lamp is carried out by various exhibits, while a large allegorical picture is exhibited, representing a "ghost" of a huge Edison lamp rising from out the windows of the old Edison laboratory at Menlo Park, and throwing rays of light from New York to all parts of the world—England, Japan, Russia, Africa, and South America. Electric meters, electric instruments, and electric pens are shown and, of course, the phonograph is in full blast with a long tail or "queue" of French visitors to listen to the sound of their own tongues. In fact, the endeavour has been to show at least one specimen of every important invention of Edison at this exhibit, and its crowded state indicates its popularity. Not far away the Thomson-Houston systems are exemplified: the celebrated Thomson-Houston arc-lighting system; the incandescent lighting in parallel and in series; the transmission of power; and the greatest of electrical practical novelties, the Thomson system of electric welding. Here might be seen Prof. Elihu Thomson himself enjoying the inspection of his own creations, while Mr. Meech and Mr. Downs entertained Lord Hartington with an exhibition of the welding.

A little way down in one of the cross aisles, superintended by Mr. A. Graner, secretary of the company, is at last in Europe the wonderful Heisler system of incandescent series lighting, which is achieving such marked success in many American towns. The Heisler lamps are 10 to 500 c.p., and can be turned off or on as desired, and are furnished with automatic cut-outs, and a very ingenious automatic regulator near the dynamo inserts resistance or shifts the brushes and keeps the potential constant. On a single line of No. 6 wire the whole lighting of a town's streets, with private or public buildings also, are connected in series, and yet the brushes of the dynamo have no greater difference of potential than 65 volts. We shall probably hear more about this system later on in England. The Sperry dynamo is just by: a machine with a hollow armature and field-magnets, both inside and out. The Sperry electric coal-cutter is shown on the same stand, a tool looking like a kind of noisy demon with a motor inside it, which deals continually violent digs or pecks—here at nothing—but in use, at the coal seams underground. The actual apparatus exhibited has already cut some hundreds or thousands of tons of coal in America. The Bell telephone is exhibited in all detail in the Palace of Industry adjoining; and Professor Elihu Thomson also shows a collection of his various electrical inventions in the same building. In an annexe to the Palais des Machines, the railway carriages find place, and here we find the Thomson-Houston electric street railway cars. The Sprague Company are also to exhibit, but they are one of the few exhibitors who are not yet in their places.

Coming now to the Continental exhibits, there is nothing but praise to be said of the energy and enterprise shown in the bringing of such a vast collection of machinery together, and of the ingenuity and skill displayed in the design and manufacture of many of the machines. Messrs. Sautter, Lemonnier, et Cie., who supply the light for the Eiffel Tower, fill a central position with a building representing the top of a lighthouse fitted with revolving electric light in all details. This is surrounded at the base with ship dynamos, portable installations for war purposes, and dynamos for torpedo boats. Maison Breguet have an immense Desrozier dynamo of 144,000 watts—the new type of dynamo with no copper, but iron wire only in its armature. The original Desrozier dynamo is also shown, and they have also a large and interesting exhibit of other electrical machinery. Messrs. Cuenod, Sautter, et Cie. show a compact six-pole dynamo of 105,000 watts, which has already been sold eight times over; and the Société Alsacienne show dynamos of 500 amperes, constructed with solid steel commutator bars simply insulated in air, which are also greatly admired, and have been sold six times over to a central lighting company. The same company show an immense dynamo coupled direct to an engine with revolving magnets and stationary outside ring armature, of which the copper sections are exposed to the air. Of Parisian companies, the Compagnie Continentale Edison has a large show in the Palais des Machines, besides a complete central station in conjunction with Messrs. Weyher et Richmond and Messrs. Belleville in the grounds. The Gramme Company exhibit dynamos and motors, and Victor Poff has a most interesting exhibit showing the compressed-air system. The Gramme Company have also a central station, the power, as mentioned, being supplied by Davey-Paxman, and they have also a large exhibit of dynamos and motors in the centre of the Palais des Machines. The Société pour la Transmission du Force par l'Electricité has a splendid double dynamo, while the Swiss firm of Oerlikon have a magnificent exhibit of an immense 600-h.p. generator and 300-h.p. motor of the same type, to which power is transmitted.

It will be impossible to mention all the interesting exhibits even thus briefly. We must content ourselves now by alluding to the new dynamo by Rechniewski, whose magnets and armature-core—the whole machine, in fact—are entirely built of iron plates; the Société Electricité et Hydraulique, near Edison's stand, with a turbine and dynamo in a street lamp-post, as used in Liège; Messrs. Serpollet Frères with their inexplodable boiler (this is at the same place as the Ferranti station); M. Paul Cadot and M. Julien with accumulators, the latter with a full exhibit of electric traction; H. Pieper, of Liège, and P. Jaspar, of Antwerp, have large exhibits, all in the Palais des Machines; the Société Cance show their arc lamps, and Gerard his lamps and dynamos; A. de Méritens et Cie. show their lighthouse dynamos and arc lamps, and also a wonderful process for destroying microbes in wines or liqueurs by *alternating* currents; M. Trouvé exhibits his motors, lamps, and instruments; M. Guyenet and the Compagnie Electrique show motors as applied to cranes, twist drills, lathes, and pumps. The French Government has sent a large collection of telegraphic apparatus.

Of the engines, we should like to call attention to Galloway's and Davey-Paxman's. The Bémer heat-engine is interesting, driving a dynamo at the very end of the Palais, while the straight-line engine is well worthy of a visit—a 100-h.p. engine in the space of 12ft. by 7ft., and 7ft. high. There are no backings whatever, and the valve has automatic cut-off and variable lead at the same time,

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regulated directly by the load on the pulley. It is also fitted with a new invention of steel wire belting, made out of rings of steel twisted, rolled, and tempered. The French and Belgian engines form a magnificent collection, and engineers will doubtless spend some time with these, but we have left these in preference to things specially electrical.

It is impossible to see or mention all in one visit. Out of some three or four hundred exhibitors in the electrical section we have mentioned the principal ones, and shall return to these and others that are interesting more in detail. Outside, in the grounds, Messrs. Galloway's electric fountain scintillates and flashes as of old. Above all the Eiffel Tower is outlined against the sky, flashing from the summit in the darkness. All around are myriads of blue and yellow lights. It grows late, the people are going, and we go too.

A PRACTICAL DETAIL OF TELEGRAPH CONSTRUCTION.

The height of the supporting posts in a line of telegraph should be accurately adjusted to the inequalities of the ground to avoid sudden and heavy gradients. This, at all events, is the theory of scientific construction, but the practice, it is to be feared, frequently falls short of this ideal. The "rule of thumb" is followed, and the foreman "trusts to his eye" with more or less success. On high roads or railways in Great Britain it is comparatively easy to attain to some degree of regularity without taking levels, but in uneven, hilly country the assistance of an instrument of some kind becomes essential if the best results are to be attained. A really well-built telegraph line is a pleasing sight when viewed from some eminence as it winds in gentle curves across the valley beneath, and is presently lost to view amid the opposite chain of hills, its wires hanging freely in graceful undulations from supports of suitable height. Not only are we conscious that care has been taken with the "survey," but we feel that every post and every insulator is doing its fair share of the work and no more, the general effect being to secure the maximum of strength and freedom from possible "faults."

As far back as 15 years ago the importance of having some definite system of surveying to work upon was recognised in far-off Japan, and men were trained in the use of appliances of a simple character, whereby it became practicable to approach very nearly to perfection in the construction of cross-country lines. The ever-present bamboos made admirable flag poles, and by having a mainmast and a topmast, so to term them, connected by iron rings whereby the topmast could be slid upwards to the extremity, if need be, of the mainmast, and held in position at any fixed point until the precise height of the flag from the ground could be actually measured off in feet and inches, it become tolerably easy to determine what should be the length of the post subsequently to be erected on any given spot. Five or six men standing at points fifty to sixty yards apart held up these flags, and raised or lowered them a few inches at a time by signal, until the altitudes had been sufficiently adjusted; numbered pegs were then driven in to mark the sites for the holediggers who followed, and all particulars entered in the survey-book.

The writer found in practice, however, that even better results were to be attained by using a rough form of theodolite, and taking levels from peg to peg, after suitable positions for the poles to be erected had been determined by actual inspection. It was rarely feasible to preserve equality in the length of the spans, as so much depended on the nature of the soil, the relative position of the proposed posts to pathways and buildings, and the many other important considerations demanding the attention of the surveyor.

An ordinary theodolite would have taken too long to adjust, but a rough substitute was made for a small sum, by which the levels were ascertained within an inch or two. A small circular table, a foot in diameter, was mounted on a light pedestal, 4ft. 6in. in height. The edge of the table was divided in 360deg. A spirit-level was attached to a sighting tube, and mounted above the disc in such a way as to give both vertical and horizontal movement in a rough imitation of an actual theodolite. One man carried forward this instrument, which weighed only 5lb., from peg to peg, whilst another marched on by similar stages carrying a rod marked in feet and inches. It was the work of a moment to note the amount of rise or fall to the next peg, and simultaneously to note the angle in which the peg beneath the theodolite stood with regard to the one behind it and the one in front of it. By this means not only could the required length of any given pole be calculated to a nicety, but the *angular strain* upon it being also known, the surveyor was able to say what support, in stays or struts, it should receive to enable it to withstand the pressure.

The entries in the field-book took somewhat the form appended:

1 Site of pole.	2 No. of pole.	3 Rise or fall to next peg.	4 Angle.	5 Height above ground.	6 Depth of hole.	7 Sup-port.	8 Remarks.
		Ft. in.	Deg.	Ft.	Ft.	Ply.	
Edge of high road	31	4 6 F.	10	20	5	5	Gate of Takeda-mura (village)
Do.	32	3 6 R.	15	19	5	5	—
Side path-way	33	2 0 R.	17	19	5	7	—
In rice field.	34	7 6 F.	13	24	5	5	—
High road...	35	4 0 R.	8	18	5	Strut	Tow'rds Imbé-mura.

The trouble taken at the outset in this way was productive of very satisfactory results, for the native foreman, having been furnished with the figures in columns 5, 6, and 7, was enabled to carry out the surveyor's design with confidence and accuracy.

In a country where native labour alone is available, and that unskilled, it is impossible to leave anything to the discretion of the workman. Every detail must be furnished, "cut and dried" for use. In the case of Japan the men were very intelligent, and accustomed to working on hard and fast lines. They were to be relied upon to adhere to the pattern provided, whatever it might be, without the deviation of a hair's breadth.

At first sight it might be supposed that the use of even the very rough apparatus indicated would be superfluous, and five out of every six of our own men will declare that nothing of the sort is necessary, as they can "guess it near enough." The writer believes that guesswork should be abolished in telegraphic construction as in other fields of labour, and that lines will last the longer and develop fewer "faults" for being built upon some approach to scientific principles.

If this be true of lines of telegraph, surely the argument applies with tenfold force in regard to telpherage. It is of the utmost possible importance that the supports of a line, such as that now in operation at Glynde, should be so adjusted as to reduce the inequalities of the route which it traverses to a minimum, and to effect this something more than the unassisted eye becomes requisite. J. M.

A STANDARDISING LABORATORY.

On Wednesday, a joint deputation of the London Chamber of Commerce and the Institution of Electrical Engineers had an interview with Sir Michael Hicks-Beach at the offices of the Board of Trade, to urge the Government to establish an electrical standardising laboratory. The President of the Board of Trade was accompanied by Lord Balfour of Burleigh, Mr. Calcraft, Mr. Courtenay Boyle, Sir Thomas Blomfield, Major Marindin, and Major Cardew. The deputation consisted of Sir William Thomson, president of the Institution of Electrical Engineers, Lord Rayleigh, Sir Douglas Galton, Sir Vincent Barrington, Profs. George Forbes, Silvanus Thompson, Perry, Hughes, Adams, and

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Foster, Major Flood Page, General Webber, and Messrs. Crompton, Fleming, Lant Carpenter, Trotter, Kapp, and F. H. Webb, secretary of the Institution of Electrical Engineers.

Lord Rayleigh, in introducing the deputation, said that Lord Crawford would have been present, but was detained at the London Electric Works at Deptford receiving a large number of American engineers interested in electricity. Lord Crawford had, however, written a letter dealing with the points that he would have touched upon. Lord Rayleigh then read a letter from Lord Crawford stating that had he been present he would have "drawn attention mainly to the requirements of undertakers as affected by the clauses of the provisional orders, and to show that obligations are put upon them to supply all descriptions of instruments for measuring quantity or pressure of an electric current. . . Every consumer has a right to claim a meter which must be a certified meter. . . . There are presently existing good and reliable forms of this instrument, but, owing to the want of reliable standards, instruments are often found to vary as much as 8 to 10 per cent." The letter further stated that "the Department should without delay inaugurate a laboratory, where we may send in our instruments to be passed in a manner similar to the procedure in the Weights and Measures Act. I think there is but little doubt that such an establishment would very shortly pay its way, and would not be a burden on Her Majesty's Treasury. . . . . A small fee for certificates would suffice to pay the expenses of such a laboratory, as, in addition to large numbers of new instruments, every time that an old one is interfered with for cleaning, etc., it will have again to be certified." Lord Rayleigh urged that the time had arrived when there was a certainty of an electrical supply on a large scale. That supply could not be afforded in accordance with the terms of existing legislation without the use of certified instruments, and at the present time there was no means of getting such certification. By the Act of last session electrical engineers were to issue certified standards, but there was at present no means of obeying the law.

Sir William Thomson then read the joint memorial of the London Chamber of Commerce and the Institution of Electrical Engineers, as follows:

"1. That it is impossible that the supply of electrical energy under statutory powers can be efficiently carried out without the provision of some means of standardising the meters and other instruments used in connection with such supply. 2. That the Board of Trade has recognised the necessity for this by inserting in licenses and provisional orders clauses requiring that these meters, etc., shall be of a pattern approved by the Board of Trade and certified as correct by a properly appointed inspector. 3. That the ordinary trade in electrical machines and instruments is much hampered and rendered uncertain by the want of generally recognised standards of electrical quantities. 4. That the required standards should be maintained by the Board of Trade as the department of Government entrusted with the administration of the Electric Lighting Acts, and as the warden of the standards of quantities used in other trades. 5. That, being strongly impressed with the absolute necessity for the establishment of a standardising laboratory where measurements of the various electrical quantities could be effected with the requisite precision, and whence certificates could be issued which would be accepted generally, the Electrical Section of the London Chamber of Commerce approached the Council of the Institution of Electrical Engineers on the subject. 6. That in consequence a joint committee of the two bodies was appointed to consider the matter, and that this committee has arrived at the following conclusions: (*a*) That the absolute value of the accepted units of the various electrical quantities has now been determined with such accuracy that the possible error cannot exceed 1-400th, or one quarter per cent. The most recent determinations may therefore be taken for practical purposes as correct, and no future corrections vitiating previous certificates need be apprehended. (*b*) That instruments and methods are now available by means of which the constancy and accuracy of measurement of electrical units and multiples of these units in a properly-equipped laboratory, and under proper supervision, can be assured. (*c*) That the cost of establishment of such a laboratory exclusive of building on the smallest scale suitable for the present requirements of the trade will not exceed the sum of £4,000. (*d*) That the joint committee aforesaid has devoted much time and consideration to the question, and the estimate at which they have arrived is as close as it was possible to make. (*e*) That they further are of opinion that by charging moderate fees for comparisons and certificates the Board of Trade would be in a position to remit the Treasury interest on this outlay, and also to provide a fund for maintenance and possible extension of the laboratory. 7. That we have now the honour to bring the above-mentioned facts to your notice, and pray that they may receive the serious consideration of the Board of Trade."

From a scientific point of view the possibility of electrical measurement had become demonstrated within the last few years very much through the labours of Lord Rayleigh, who had given them a correct determination of the standard of resistance. Unless they had instruments to test with accuracy, it would be impossible to work out the Electric Lighting Act.

Sir Vincent Barrington, on behalf of the council of the London Chamber of Commerce, said that they had unanimously determined to support this movement.

Mr. Crompton said those engaged in the work of electricity were placed at a considerable disadvantage with foreigners, who had the advantage of making the whole of their instruments and sending them for certification to Berlin and Paris, where standardising laboratories had been established by their respective Governments. When instruments were thus certified, they had a higher commercial value in the markets of the world than our instruments that had no such certification.

Sir Michael Hicks-Beach, in reply, said they had been speaking on a subject of a highly technical character with which he could not pretend to be specially conversant. He thought in principle there were very good grounds indeed for their request, and more than that he could not say at present, but he would look very carefully into it. He should, of course, have to bring the subject, if he felt able to do so, before that rather difficult department, the Treasury. He thought that they had put before him very good grounds for some such provision being made as they had requested.

Lord Rayleigh having thanked the right hon. gentleman, the deputation withdrew.

COST OF MAINTENANCE.

The following figures are given as to the cost of the electric light at the Moliere Mines. A Brush dynamo lights 16 arcs, of 75 carcels, and gives at 1,000 revs. 839 volts at 9 amperes. The cost of the installation was 20,389f.—thus:

Engine and Gearing	5,400f.
Brush dynamo	6,000
Lamps	3,840
Cables	1,380
Installing	3,769
	20,389

The installation has been working since 1884, as the following will show:

Year.	Total Cost.	Hours Light Used.	Per Hour Cost.	Per Lamp Hour.
1884	1,728·85f.	370	4·67	0·28
1885	3,149·95	669	4·70	0·28
1886	2,126·90	608	3·49	0·20
1887	1,985·40	507	3·91	0·23
1888	1,311·55	440	2·98	0·18
	10,302·65	2,594	3·95	0·23

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IMPORTANT NOTICE.

The index of the current volume will be given with our next number, and every purchaser should receive it free of cost.

We commence our report of the Paris Exhibition with a general article on the exhibits in this issue, and the descriptions of special exhibits will appear from time to time till the whole have been described.

Specimen copies of the paper will be sent on request.

THE PARIS ELECTRICAL CONGRESS.

If the French do not initiate much except exhibitions and congresses, they always manage to obtain a good deal of the world's attention in some way or other. Above all things, they are great on congresses. Some sixty-five have been arranged to be held during this year's Exhibition, and no doubt each one will satisfactorily settle some question or other. However, to the phlegmatic Dutch or Englishman the congresses resolve themselves into paying *vingt francs*, and getting nothing for it. A certain number of ardent spirits are always ready to provide the "francs," and to believe the talkee-talkee that goes on in the meetings is really good and valuable work. To those who have only "vingt francs" for congress or theatre, we say take the latter. We have before us a programme of the Electrical Congress, and our investigation of the programme—or our ignorance of a foreign tongue—leads to the conclusion that it has no "objective."

The Congress of 1881 always seemed to us a mistake, and it is now paraded before us as an epoch marking date when practical units were determined. The ten years' agreement which then took place has had no effect at all, either in the workshop or in the laboratory, nor would an agreement come to-morrow by a score or two of congressists to call the "yard" or "foot" by some other name, have any effect in assisting to better construct a dynamo, railway line, or Forth Bridge. This programme tells us that 1889 offers a natural occasion to complete the work of 1881. Small boys who have flower gardens are often seen pulling up their plants to see how the roots are getting on; they do not understand that the plants thrive best by being left alone. And this is the case with some people with "measures and units"; they want to be everlastingly tinkering and changing in order to get an "ideal" system. Orthodox and heterodox. The former are those who bow down and worship the dozen change-ringers, the latter are all the other nobodies. We prefer something settled and the nobodies. Was it not a Quaker who, acting on the defensive, pushed back an aggressor with "Thee is not wanted here"? Uncle Tom can tell, but with regard to measures and units we say, Let us have peace.

It is quite time a stand was made against the actions of those who have no object in life but to propose, agitate, and change, and we shall be prepared to view with disfavour any attempt to impose any alteration in our practical units. If the framers of this programme had contented themselves with discussing certain interesting practical questions, obtaining thereon a consensus of practical opinion, we could have supported it without a word of adverse criticism. The practical man does not at the present time require a lot of scientific finesse upon questions of minutiæ, but he wants to know

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how his colleagues in various parts have overcome the practical difficulties that arise in constructional and installation work. He does not care a fig whether the ohm be 102·3 or 102·34 mm. of Hg with a given sectional area, but he does want to know if any colleague has left the trammels of "percha," "rubber" and Co., and gone into something new for insulation of high pressure. Like the gas manager, too, he wants to know how best to keep down leakage. He knows something of what can be done with the A. T. distributing system, also with the B. T. system, but the experience is comparatively limited, and with comparatively small installations, so he wishes to collect all the information he can. Then patentees and promoters tell us on paper that this method of traction is cheaper, and that this or that apparatus is economical. The manufacturer and the user both want actual figures, not hypothetical ones. A congress that would bring out information on these and on a hundred similar questions would indeed be valuable. Pile up your experiences, not your theories. Let history slide in the face of present practice. Time moves too quickly to trouble about what was done in 1881 or 1886. What is being done in 1889? is the question. The answer would enable us to avoid the errors of 1881 and of 1886, though those of 1889 will exist, and only the future will teach how to avoid them. If our suggestion could be carried out, nothing should be said at the congress except to describe apparatus in actual work—its successes and its failings—and apparatus installed since, say, January 1st, 1888. Apparatus untried should be as rigidly tabooed as references to the stone or bronze age.

The programme shows the work of the eight days from August 24th to be divided among six sections dealing respectively with (1) Measures; (2) Dynamos, Transformers, Distribution; (3) Electro-Chemistry; (4) Lighting; (5) Telegraphy with sub-sections Telegraphy, Telephony, and Various Applications; (6) Electro-Physiology. Now, in the first place, who are the men going to provide the papers to be discussed? Are they of the workshop, or are they of the study? The promotors of the feast should give some idea of what they will provide to enable the would-be guest to see if value for "vingt francs" is to be given. If we remember rightly, in 1881 the congress was followed by the establishment of an International Electrical Society. What has that society done? Does it still exist? and have the members been quite satisfied with its working? We are quite willing to assist society, congress, or exhibition that appears likely to do some good, but these mutual admiration congresses, got up for the glorification of the few at the expense of the many, leading to no general benefit, are to be condemned.

There seems to exist amongst the dilettanti an hereditary inability to see the problems of the day, and complete failure to grasp that which is important and that which is unimportant. The motto of the Royal Agricultural Society might be well kept in view—"Experience with Practice."

MAGNETISM IN ITS RELATION TO INDUCED ELECTROMOTIVE FORCE AND CURRENT.*

BY ELIHU THOMSON.

There is perhaps no subject which at the present time can have a greater interest to the physicist, the electrician, and the electrical engineer than the one which heads this paper. The advances which have been made in the study from its purely theoretical or scientific side, and the great technical progress in the utilisation of the known facts and principles concerning magnetic inductions, can but deepen and strengthen that interest.

On the side of pure theory we find the eager collection of experimental data to be submitted to the scrutiny of the ablest and brightest minds, to be examined and reasoned upon with the hope of finding some clue to satisfying explanations, and, on the side of practice, we find the search for new facts and relations no less diligent, though often stimulated by practical problems presented for solution. Indeed, the urgency for results is often the greater on the practical side, for theory can wait, practice cannot, at least in the United States.

We must look for continued triumphs in both directions, and the most welcome of all will be the framing of a theory or explanation which will enable us to interpret magnetic and electric phenomena. The recent beautiful experiments of Hertz on magnet waves have opened a fertile region for investigation.

It would seem that the study of magnetism and electricity will give us the ability to investigate the ether of space, which medium has been theorised upon at great length, with the result of leaving it very much where it was before—a mysterious necessity. Faraday says, speaking of magnetism: "Such an action may be a function of the ether, for it is not at all unlikely that if there be an ether it should have other uses than simply the conveyance of radiations." 3,075. Vol. iii., Exp. Res.

"It may be a vibration of the hypothetical ether, or a state of tension of that ether equivalent to either a dynamic or a static condition, etc." 3,263. Vol. iii., Exp. Res.

Faraday again says, speaking of the magnetic power of a vacuum: "What that surrounding magnetic medium deprived of all material substance may be I cannot tell, perhaps the ether." 3,277. Vol. iii., Exp. Res.

Modern views would seem to point that through a study of magnetic phenomena we may take a feeble hold upon the universal ether. Magnetism is an action or condition of that medium, and it may be that electrical actions are the expression of molecular disturbances brought about by ether strains or interferences. The close relations which are shown to exist between magnetism and light tend to strengthen such views. Indeed, it would not be too much to expect that if the mechanics of the ether are ever worked out we should find the relation between sensible heat and electric currents to be as close as that of light to magnetism, perhaps find ultimately the forms of matter, the elements and compounds to be the more complex manifestations of the universal medium; aggregations in stable equilibrium. It is a difficult conception, I confess, and a most shadowy and imperfect one, yet facts and inferences which favour such views are not wanting.

Our science of electricity seems almost to be in the same condition that chemistry was before the work of Lavoisier had shed its light on chemical theory. Our store of facts is daily increasing, and apparently disconnected phenomena are being brought into harmonious relation. Perhaps the edifice of complete theory will not be more than begun in our time, perhaps the building process will be a very gradual one, but I cannot refrain from the conviction

* Paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.

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that the intelligence of man will, if it has time, continue its advance until such a structure exists.

I have been led to make these general allusions to electrical theory in order to emphasise the fact that in the present paper no unravelling of the mystery is to be attempted, but rather the presentation of some few considerations upon a subject of absorbing interest.

The conception of Faraday in regard to the existence of lines of magnetic force representing directions of magnetic strain or tension in a medium has not only lost nothing of its usefulness up to the present time, but has continually been of great service in the understanding of magnetic phenomena. We need spend no time in showing, as Faraday and others have done, that these lines are always closed circuits, polarised so that the direction of the lines cannot be reversed without reversal of the actions. Nor need we take time to show that in any medium the lines are mutually repellant laterally if of the same direction of polarisation. Opposing this tendency to separation or lateral diffusion of magnetic force is the strong apparent tendency of the lines to shorten themselves in any medium. These actions are disturbed by the presentation of a better medium, as iron instead of space or air. Lines of force will move into the better medium, having apparently the constant tendency to diminish the resistance in their paths.

The peculiar and mysterious nature of media such as iron is to permit an extraordinary crowding of lines on account of slight resistance to their passage through it. We need not, in addition, do more than refer to the other well-known facts of an electric current developing magnetic lines encircling the conductor, as being the general type, which includes all forms of magnetic field, or electro-magnets, sustained by currents, and the fact of a development when magnetic lines or circuits and material masses are in relative movement of E.M.F.'s transversely to the direction of the lines of magnetism and also transversely to the direction of relative movement, as in the case of electric conductors traversing or cutting through a field, or a field traversing or being moved across a conductor. We must not forget that even insulators, as well as conductors, cutting lines of force, have the E.M.F. developed in them. The action simply develops potential difference, and this generates the current where a circuit exists. While we are in the habit of saying that a conductor moved across a field of lines, or *vice versa*, generates electric current, I think the statement incomplete. The movement only sets up a potential difference and the power expended in effecting the movement generates C × E. The current is energy less the potential, or the energy expended gives the two effects of potential or pressure, and current or rate of movement. Consequently, an insulator, or an open-circuited conductor, traversing a field, consumes no energy, potential difference only being produced. Nevertheless, as will be shown, the magnetic circuits or lines themselves may furnish the energy for their own movement across a conductor, and so develop current as well as potential. This occurs in the effort of lines to shorten their paths, to lessen their density, to pass to better media. Indeed, a close examination will show that wherever power is expended in developing current in a circuit, cutting lines of force, the energy expended is first employed in stretching the lines, which thus receive the energy required to permit them, in shortening, to cut the conductor and set up currents in the electric circuit in accordance with the potential difference developed in that circuit and its resistance.

I think, we may also say, though I do not remember to have seen the statement so put, that whenever electric potential is set up inductively, as in self-induction, mutual induction, induction from one circuit to another and induction from magnets or magnetic field, it is set up by the movement of lines of force laterally across the body, mass, or conductor in which the potential is developed, and that whenever current is set up in a wire or an existing current prolonged, or an existing current checked by induction, self-induction or induction from magnets, the action is a transfer of energy, represented by strained lines of force shortening or lessening their resistance, or lengthening and increasing the resistance in their paths. The magnetic field is like an elastic spring: it can in one condition represent stored energy—it can be strained and will store energy—it can be made to relieve its strain and impart energy.

Let us examine some known phenomena in this light. Take the case of a simple wire, conveying current, say, in a line away from the observer, Fig. 1. There exists a free field of circular magnetism (so-called), shading off away from the wire, and which is represented by concentric circles of increased diameter. The superior intensity or strength of the lines near the wire may also be represented by their thickness. This is often shown also by crowding the lines near the wire, though I am disposed to regard Fig. 1 as more nearly expressing the condition, unless we are to regard the lines as simply indicating a sort of atmosphere of magnetic effect whose density becomes less as we proceed outward from the wire, in which case either form of symbol suffices. The direction of polarisation of the lines may be indicated by an arrow-head pointing in a direction of right-handed rotation in the path of the lines. This is, the typical figure or expression for all forms of simple magnetic circuit—the form of the lines, their length, position, density, will depend on the shape of the conductor or conductors (when more than one) and the materials surrounding or in proximity to the wire or wires.

If the current traversing the conductor is constant, the magnetic field around it is stable and static, unless other influences come in to modify it. The cutting off of the current is followed by instability of the field whereby it can and must produce dynamic effects. I say *must* because the field represents stored energy and in disappearing *must* give out that energy. To throw light on this part of the subject is one of the objects of the present paper. Cutting off the current supply in the case assumed leaves the developed magnetic lines or strains unsupported, they at once shorten their paths or circuits, collapsing upon the conductor, as it were, and, continuing this action, cut the section of the conductor, and apparently disappear in magnetic-closed circuits of infinitesimal diameter, but of great strength of polarisation. It appears to me that we must either be prepared to give up the idea of lines of force, or take the position that the magnetic circuits precipitate themselves in shortening their circuits, and disappearing upon and cut the conductor. It was Hughes who put forward the idea that an iron bar, in losing its apparent magnetism, really short-circuits the lines in itself as innumerable strongly-magnetised closed circuits among the molecules. In becoming magnetic once more, these short circuits are opened or extended into the air by some source of energy applied to strain the lines, such as a current in a conductor around the bar.

May not this idea be extended, then, to include the magnetic medium, the ether itself? Does it contain intensely polarised closed circuits of magnetism which are ready to be stretched or extended under certain conditions by the application of energy, which energy is returned by the collapse of the extended circuits? This is doubtless but a crude expression of the real condition of things, for the lines are only symbols for a condition of strain in a medium which cannot be represented in thought, as we know nothing of its real nature. There is one point in this connection which I must emphasise. The strained lines, Fig. 1, are indications of stored energy in the ether, and the lines *cannot* disappear without giving out that energy. Ordinarily, it makes it appearance as the extra current, and adds itself so as to prolong the current which extended the lines when an attempt is made to cut off such current. Were it conceivable that the current could be cut off and the wire put on open circuit while the lines still remained open or strained, the energy must still escape when the field disappears. It would then produce such a high potential as to be able to discharge from the ends of the conductor, and if the conductor were of some section, part of the energy would be expended in setting up local currents in it. The field could not disappear without an outlet for the energy it represents. But we cannot cut off a current in a wire so as to leave the wire on open circuit with the lines of the magnetic circuit remaining around it without iron or steel or the like in the magnetic circuit. We can approach that condition, however

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by breaking the circuit very quickly with a condenser of limited capacity around the break. This is done in the Ruhmkorff coil primary. The condenser forms a sort of blind alley for the extra current on its beginning to flow out of the primary coil; but the condenser charges and backs up and stops the discharge from the primary, even giving a reverse current. The lines of magnetic force collapse, however, and have their effect in the enormous potential set up in the secondary coil.

Take away the secondary coil so as to stop that outlet, the energy expends itself on the iron core and the primary coil. Take away the iron core, and the energy of magnetisation of the air or ether core expends itself on the wire of the primary, and possibly, also, on the dielectric of the condenser to some extent. The extra current becomes in this instance an oscillatory discharge of very high period back and forth through the primary coil from the condenser, until the energy is lost in the heat of $C^2 \times R$. This conversion is doubtless rendered all the more rapid by uneven distribution of current and eddy current set up in the wire of the coil.

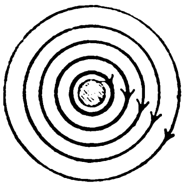

Fig. 1.

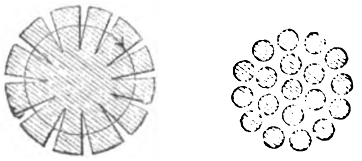

Fig. 3.

The considerations just given concern the loss of field or the shortening and apparent disappearance of the magnetic lines or circuits, as g'ving rise to the self-induction or increased potential on breaking. Where the energising current is slowly cut off or diminished the energy is gradually transferred to the wire in producing elevation of potential during the decrease; and the collapse and cutting of the wire by the collapsing circuits or lines is then only more gradual.

Let the current be returned to the wire after disappearance of magnetism, and the lines again seem to emanate from the wire and at the same time cut it and produce a counter potential in it, which is the index of the abstraction of energy from the circuit, and its storing up in the form of elastically strained lines of magnetism around the conductor. The effect is that of self-induction on making or upon increase of current, the measure of the amount being the

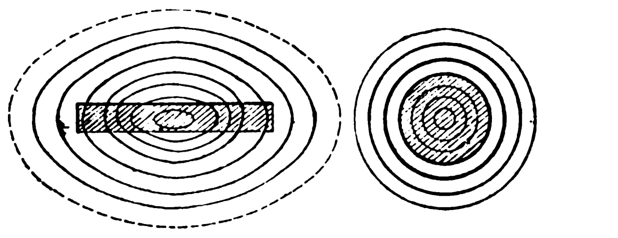

Fig. 2.

energy stored in the magnetic circuits which have been extended or opened up by the current. The greater the current and the shorter the path for the lines developed around the axis of the conductor, the greater the energy stored up. Hence, a circular section conductor has the highest self-induction, a tube of same section less as its diameter increases, a flat strip has less as its width increases and thickness diminishes, a divided conductor much less than a single conductor of same shape and section. Separating the strands of a divided conductor increases the length of magnetic paths around it, and so diminishes the self-induction. A striking instance of this latter fact was developed in conveying very heavy alternating currents of very low potential a distance of about three feet by copper conductors, the current being used in electric welding operations.

The conductors were built up of flat thin strips of copper for flexibility. When the strips were allowed to lie closely together the short conductor showed an enormous self-induction, which cut down the effective potential at its ends near the work. By spreading apart the strips, so as to lengthen a line around the conductor, the self-induction could be easily made less than 35 per cent. of what it had been before. The interweaving of the outgoing and return conductor strands as one compound conductor gets rid almost entirely of the self-inductive effects, because neither conductor has any free space in which to develop strong magnetic forces, but is opposed in effect everywhere by the opposite current in its neighbour.

Where a number of conductors are parallel and have the same direction of current, as in a coil or in a strand, it is evident that statically the conductor may be considered as replaceable by a single conductor with the same external dimensions and same total current in the area occupied, the magnetic forces or lines surrounding them being of same intensity. But with changing current strength the distribution of current in the conductor has also a powerful effect on the energy absorbed or given out in accordance with the magnetism produced. Hence the self-induction of a strand, coil, or conductor of the same section varies with the rapidity of current changes, owing to the conduction eing uneven.

The uneven distribution of current, or its tendency to

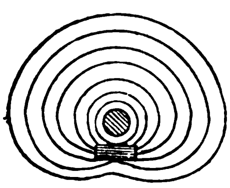

Fig. 4. a

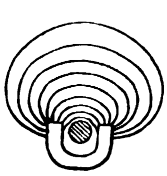

Fig. 4. b

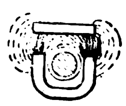

Fig. 4. c

flow on the outer parts of a conductor when the rate of variation or alternation is made great, is in itself a consequence of the fact that less energy is transferred into magnetism in this case, that when the current flows uniformly over the section or is concentrated at the centre. In other words, when a uniform current traverses a conductor of the same section the circular magnetism or surrounding magnetic lines are to be found not only outside the conductor, but also beneath its exterior. Since in forming these lines on passage of current the middle of section would be surrounded by more lines than any other

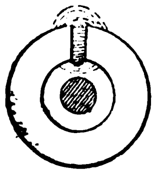

Fig. 5.

Fig. 6.

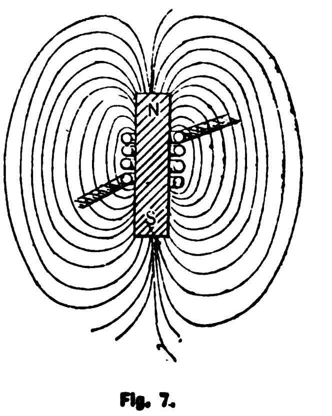

Fig. 7.

part of the conductor, the current tends to keep out of that part and move near the exterior in greater amount. Hence, in rapidly-alternating currents, the conductor section is practically lessened, being restricted largely to the outer metal of the conductor. If the round conductor, Fig. 2, were made of iron, the magnetism interior to it, and set up by a current in it, would be very much greater, the section of the conductor being filled with magnetic circuits or lines around the centre. The total magnetism, external and internal, would be much greater in this case for a given current flow, and the energy absorbed and given out in formation and loss of field, or the self-induction, would be much increased. This could, however, be greatly diminished by slitting the conductor radially, or making it of a number of separate wires out of lateral magnetic contact, one with the other, Fig. 3. In these cases the resistance of the interior magnetic circuits would be increased, as there would be several breaks in the continuity around the centre of the conductor. The total magnetism which could be set up by a current would be lessened, and the self-induction therefore, lessened.

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The moment we begin the bringing of iron into proximity with an electric conductor conveying current, we provide a better medium for the flow or development of magnetic lines or circuits. In other words, the lines may then be longer, yet equally intense, or more lines may be crowded into a given section of this metal than in air or space. Figs. 4*a*, 4*b*, 4*c* show the effect brought about by bringing iron of different forms near to the conductor.

It shows, in other words, the development of the ordinary electromagnet of the horseshoe form, and the concentration of the lines in the better medium. The lines also tend to shorten and diminish the resistance to their passage, so that attraction of the iron to the conductor takes place, and if there is more than one piece of iron they tend to string themselves around the conductor in magnetic contact with one another.

When copper bars of 1in. diameter are traversed by currents of 40,000 to 60,000 amperes, as in welding them, the magnetic forces just referred to become so enormous that very heavy masses of iron brought up to the bar are firmly held, even though the current be of an alternating character, changing direction many times a second.

When a conductor is surrounded by a cast-iron ring, as in Fig. 5, the current in such conductor has an excellent magnetic medium surrounding it. A large amount of energy is then abstracted on the first impulse of current, which goes to develop strong and dense magnetic lines through the iron ring and across the gap in it. On taking off the current the energy is returned as extra current, and its force is many times what would be found with air alone surrounding the conductor. We have then greatly increased the self-induction, the storing of energy and opposition to current flow at the beginning, the giving back of energy and assistance to the current flow on attempting to remove or stop the current. Let us now complete the ring by making it of iron, endless, Fig. 6, with the conductor in the middle.

We now find that on passing current through the conductor it meets with a very strong opposing effect or counter potential. The evolution of magnetic lines or the opening out of magnetic circuits goes on at a very rapid rate. Each line or magnetic circuit evolved and cutting the conductor, flies at once outward and locates itself in the iron ring. This ring can carry innumerable lines, and they do not crowd one another. It permits the lines even to lengthen in reaching it, and yet, on account of its low resistance to their passage, the lengthening is equivalent to their having shortened in other media. We will suppose the current not sufficient to exhaust this peculiar capacity for lines which the iron has. Equilibrium is reached, the conductor has opened up innumerable closed circuits and caused them to exist in the ring still closed, but in iron, not space or ether merely. The current passing has continued its action and storage of energy until, to emit another line in view of the resistance now found in the crowded iron ring, is impossible.

Now, let us cut off the current. We are surprised to find a very weak extra current, a practical absence of self-induction on breaking, or at least a giving out of energy in no wise comparable to that on making. Let us put on the current as it was before. Another curious result. But little self-induction now on making, energy not absorbed.

Now cut off the current again. Same effect as before. Now let us put on the current reversed in direction. At once we find a very strong counter potential or opposing self-induction developed.

The ring had been polarised, or retained its magnetic energy, and we are now taking out one set of lines and putting in reversely polarised lines of force. This done, we break the reversed current without much effect of self-induction. The ring remains polarised and inert until an opposite flow of current be sent through. Iron is then a different medium from the ether.

The ring once magnetised must in losing its magnetism permit a closure of the lines by shortening. This involves their passage from the iron across the space in the centre of the ring, notwithstanding its great resistance to the lines of force. As passage from iron to air is equivalent to lengthening of the lines it is readily seen that such lengthening may oppose more effect than a slight shortening due to leaving iron, for air or space may give in provoking a closure and disappearance of the lines. Looked at from another standpoint, the lines on the iron may actually require a small amount of initial energy to dislodge them therefrom, so that after being dislodged they may collapse and yield whatever energy they represent.

I must reserve for the future further consideration of the iron ring, but in thinking upon this matter I am led to think that the production of a magnetic line in an iron ring around a conductor may represent a sort of wave of energy, an absorption of energy on the evolution of the line from the conductor, and a slight giving out of energy on the line reaching that position of proximity to the iron ring that its passage thereto may said to be a shortening process or a lessening of its resistance.

The magnetism in air, gases and non-magnetic bodies, being assumed to be that of the ether, this medium shows no such effects as those we get with the ring. It does not become permanently polarised, as does even soft iron under the condition of a closed ring. The iron possesses coercive force, or magnetic rigidity, and a steel ring would show more of it. The molecules of the iron or steel take a set. If we were to cut the soft iron ring, or separate it in any way, this introduction of resistance of air for ether in the magnetic circuit would cause the lines to collapse, and set up a current in the conductor. The energy of the ring would have been restored to the latter. The curious thing is that physically the polarised ring does not present any different appearance or ordinary properties different from those of a plain ring, and will not deflect a compass needle Its condition is discoverable, however, by the test of self-induction to currents of different direction. As a practical consideration, we may mention in this connection that a self-inductive coil for currents of one direction must be constructed differently from one to be used with alternating currents. The former must have in its magnetic circuit a section of air or the like, or be an imperfectly-closed circuit, as it were. The latter should have as perfectly-closed a magnetic circuit as can be made. We see here, also, the futility of constructing a Ruhmkorff core coil on the closed iron magnetic circuit plan, because the currents in the primary are interrupted, not reversed.

The considerations just put forward in relation to the closed iron ring, and its passive character under the condition of becoming polarised, are more important than at first appears. It has been found that the secondary current wave of a closed iron circuit induction-coil or transformer, whose primary circuit receives alternating current, is lagged from its theoretical position of 90deg. behind the primary wave an additional 90deg., so that the phases of the two currents are directly opposed; or the secondary current, working lamps only in its circuit, is one half a wave length behind the primary, instead of only a quarter wave length, as might have been expected.

But when it is understood that the iron core polarised in one direction by the primary impulse does not begin to lose its magnetism when that impulse simply weakens, but waits until an actual reversal of current has taken place, it will be seen that the secondary current, which can only be produced when magnetic lines are leaving the core and cutting the secondary coil, or when the lines are being evolved and passing into the core from the primary coil, will have a beginning at the moment the primary reverses, will continue during the flow of that impulse, and will end at substantially the same time with the primary impulse, provided the work of the secondary current is not expended in overcoming self-induction, which would introduce a further lag. Moreover, the direction of the secondary current will be opposite to that of the primary, because the magnetic circuits which are opened up by the primary current in magnetising the core, or which are closed or collapsed by it in demagnetising the core, will always cut the secondary coil in the direction proper for this result. Transformers of the straight core type with very soft iron in the cores and not too high rates of alternation should approximate more nearly the theoretical relation of primary and secondary waves, because the magnetic changes in the core are capable of taking place almost simultaneously with the changes of strength of the primary current. This fact has other important practical and theoretical bearings.

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Let us assume a plain iron core, Fig. 7, magnetised as indicated, so that its poles N S complete their magnetic circuits by what is called free field or lines in space around it. Let a coil of wire be wound thereon as indicated. Now assume that the magnetism is to be lost or cease, either suddenly or slowly. An electric potential will be set up in the coil, and if it has a circuit, work or energy will be produced or given out in that circuit, and in any other inductively related to it. Hence the magnetic field represents work or potential energy. But to develop potential in the wire the lines must cut the wire. This they can do by collapsing or closing on themselves. The bar seems, therefore, to lose its magnetism by gaining it all, and in doing so all the external lines of force moving inward cut the wire. The magnetic circuits shorten and short-circuit themselves in the bar, perhaps as innumerable molecular magnetic circuits interior to the iron medium. To remagnetise the bar, we may pass an electric current through the coil. The small closed circuits are again distended, the free field appears, and the lines moving outward cut across the wire coil opposite to the former direction, and produce a counter potential in the wire, and consequent absorption of the energy represented in the free field produced. As before studied, the magnetism cannot disappear without giving out the energy it represents, even though the wire coil be an open circuit, and therefore unable to discharge that energy. The coil open circuited is static, not dynamic. In such assumed case the lines in closing cut the core and heat it. Let us, however, laminate the core or subdivide it as far as possible, and we appear to have cut off this escape for the energy. This is not really so, however. We have simply increased the possible rate of speed of closure, or movement of the lines, and so have increased for the divided core the intensity of the actions of magnetic friction and local currents in the core, the latter still receiving the energy of the magnetic circuit. This reasoning is based on the possibility in this case of cutting off the current in the magnetising coil and retaining the magnetic field. This is of itself probably impossible with soft iron. That the core receives the energy when the coil cannot is shown in the well-known fact that in some dynamos with armatures of bobbins on iron cores the running of the armature-coils on open circuit gives rise to dangerous heating of the cores, and that under normal work the heating is less. In the former case the core accumulates the energy represented in the magnetic changes. In the latter, the external circuit of the machine and its wire coils take the larger part of the energy which is expended in doing the work in the circuit. In this case, also, the current in the coils causes a retardation of the speed of change and extent of change of magnetism in the iron cores, which keeps down the intensity of the magnetic reaction. In fact, this retardation or lag and reduction of range of magnetic change may in some machines be made so great by closing the circuit of the armature-coils themselves, or short-circuiting them that the total heat developed in the cores is much less than under normal load.

I wish now, in closing, to refer briefly to phenomena of moving lines of force, and to the effects of speed of movement. In order to generate a given potential in a length of conductor we have choice of certain conditions. We can vary the strength of field and we can vary the velocity. We can use a strong field and slow movement of conductor, or we can use a weak field and rapid movement of the conductor. But we find also that where the conductor has large section it is liable to heat from eddy currents caused by one part of its section being in a stronger field than another at the same time. One part cuts the lines where they are dense and the other where they are not dense, with the result of difference of potential and local currents which waste energy in heat. We cannot make the conductor move in a field of uniform density, because it must pass into and out of the field. The conditions just stated are present in dynamos for heavy current work, where the speed of cutting of lines is low and the armature-conductor large in section.

But we find that in a transformer secondary we can use very large section of conductor, even (as in welding machines) 12 to 15 square inches solid copper, without appreciable difficulty from eddy currents in it. The magnetic lines certainly cut the heavy conductor and generate the heavy current and potential needed. What difference, if any exists? In the transformer the currents are generated by magnetic field of very low density, in which the lines are moving across the conductor with extreme rapidity. The velocity of emanation of lines around the primary coil is probably near that of light, and each line passes across the section secondary conductor in a practically inappreciable time. There is no cause, then, for differences of potential at different parts of the section heavy secondary. Then, to avoid eddy currents in large conductors, and generate useful currents in them, we may cause the conductor to be either moved into and out of a low density field with very great speed, or better, we must cause the lines of a very low or diffused field to traverse or cut across the conductor with very high velocity.

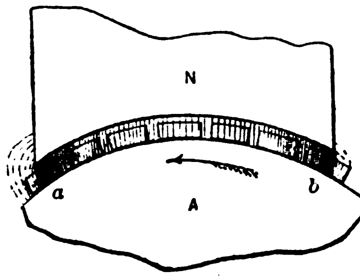

Fig. 8.

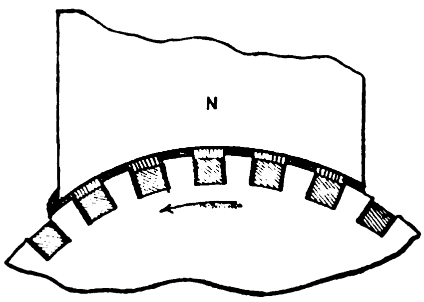

Fig. 9.

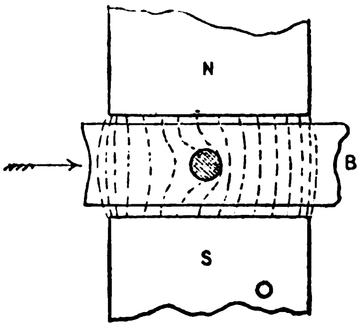

Fig. 10.

It is a known fact that in dynamos with large section armature-conductors there are less eddy currents produced in the conductors when they are provided with iron cores or wound upon iron cores, than when the conductors are made into flat bobbins moved in front of field-poles. Projections existing on the armature between which the conductors are placed have a like effect, and enable us to employ heavy bars or bundles of wire without much difficulty from local currents. The reason is simple. In the armatures with coils without iron in them or without projections extending between the turns the conductor moves into and out of a very dense field at comparatively low velocity, so that any differences of potential developed in the parts of the section of conductor have full effect and abundant time to act in setting up harmful local currents. In the cases in which iron projects through the coil or conductor the real action is that the lines of the magnetic circuits move at high speeds across the conductor, and the conductor is at all times in a field of very low density. Figs. 8 and 9 will make this plain. In Fig. 8 we have shown a smooth armature surface having a heavy conductor laid thereon, and which is at *a*, just entering a dense field at the edge of the pole N and at *b* leaving such field. It will be seen that when in such position the conductor, if wide, is subjected to varying field strength, and moves at a low speed for the generation of the working potential as it passes through the field, thus giving rise to eddy currents in the conductor.

In Fig. 9 the conductors are set down between projections, in which case both armature and field-poles are laminated or subdivided. As each projection leaves the edge of field-pole N, the lines which it had concentrated on and through it snap backward at an enormous speed and cross the gap to the next succeeding projection on the

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armature, cutting the whole section of the heavy armature-conductor at practically the same instant. This brisk transfer of lines goes on from each projection to the succeeding one in front of the field-pole, leaving a very low density of field at any time between the projections. The best results would be obtained when the armature-conductor does not project beyond or quite fill the depth of groove between the projections. Of course there are other remedies for the eddy current difficulty, notably the stranding and twisting of the conductor on the armature so as to average the position of the parts of the compound conductor.

Perhaps the most extreme case of what may be called dilution of field by projections and by closed magnetic circuits in transformers would be that of a block of iron, B, Fig. 10, moved between poles N and S, and having a hole through it, into and through which a conductor is carried. The path through the iron is so good that we can scarcely consider that any lines cross the hole from N to S, yet as B moves forward there is a continual snapping transfer of lines from the right forward side of the hole to the left or backward side, cutting the conductor as they fly across, and developing an E.M.F. in it. I have described this action more in detail because we have it in whatever distinction in the manner of cutting the lines of the field is to be found between wire on smooth armatures and on projection armatures and modifications thereof; and also between flat, open coils passing through a field and bobbins with cores of iron. The considerations advanced also bring out the relation which exists between closed iron circuit transformers and closed iron circuit (projection) dynamos, as we may call them.

I had intended at the outset of this paper to deal to some extent with the propagation of lines of magnetism undergoing retardation in reference to alternating-current motor devices, transformers with limited secondary current, or constant average current, an alternating motor working with what I may term a translation lag, etc.; but it was soon found that these matters must remain over for a continuation of this paper at some future time. My endeavour has been in the present paper to deal with the lines of force theory as though it were a symbol of the reality; but I confess that it is done with many misgivings that I may have carried it too far. Yet, if we are to use the idea at all, it has seemed but right to apply it wherever it may throw any light on the subject or assist in our understanding of phenomena.

ELECTRIC MOTOR REGULATION.*

BY FRANCIS B. CROCKER.

Although this subject is one of great scientific and practical interest, it has not been very frequently or very fully treated up to the present time. Of course, motor regulation is very similar to dynamo regulation, but it is by no means identical with it, and it deserves and requires separate treatment. I do not think it is much exaggeration to say that at the present time there is no subject more generally important to electrical engineers than motor regulation. Considering this fact, it is certainly remarkable that the literature of the subject is so limited. We find stray articles in electrical periodicals, rarely more than a description of one particular invention, and in electrical books, regulation is referred to incidentally in connection with descriptions of the various motors. There is also, to be sure, usually one short chapter devoted to this subject, but it is apt to be either very general, merely mentioning a few regulating devices, or else it is confined to the mathematical analysis of some one particular method.

Motor regulation is a subject which is somewhat confusing, and requires therefore accurate definition of the quantities and conditions which enter into it. One case is, at first sight, very similar to another, and yet, more careful consideration will show, very likely, that it is exactly opposite. Take, for example, the two commonest and most important cases—viz., the constant-potential and the constant-current motors. The conditions of the two cases are precisely opposite, and the solution of the problem is, naturally, entirely different. To maintain a motor at a constant speed with a variable load, on a constant-potential circuit, which is the case of the ordinary shunt motor on the regular 110-volt incandescent circuit, is a very easy problem—in fact, it solves itself. A simple shunt-wound motor will run at a practically constant speed on a constant potential circuit, even if the load varies from zero up to the full capacity of the motor. Now this form of motor is exactly what we would use, even if we did not care to have it regulate. It is customary, to be sure, where very close regulation is required, to wind constant-potential motors differentially—*i.e.*, with series as well as shunt-coils—but this is not essential for ordinary work.

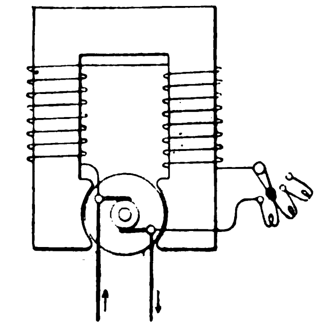

Fig. 1.—Shunt Motor with variable resistance in field circuit.

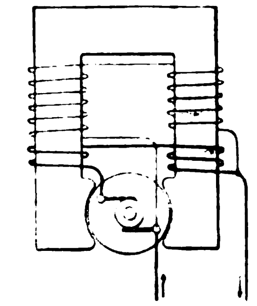

Fig. 2.—Differential motor. Self-regulating.

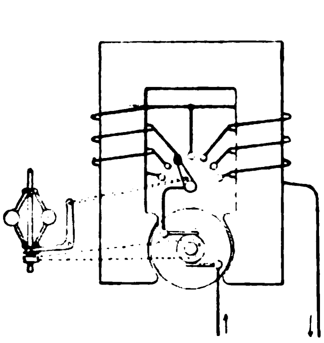

Fig. 3.—Series Motor with switch for cutting out coils in series.

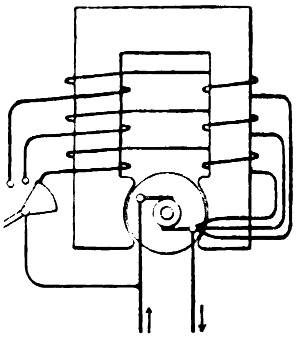

Fig. 4.—Shunt Motor with switch for cutting out field coils in multiple arc.

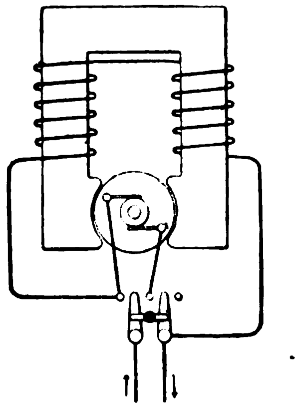

Fig. 5.—Motor with switch for throwing armature and field in series or in multiple arc.

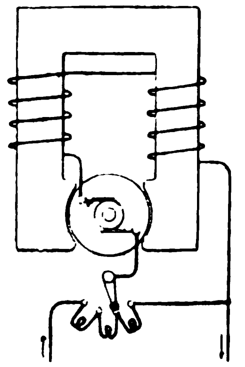

Fig. 6.—Series Motor on variable shunt.

The case of the constant-current motor, on the other hand, is as difficult as the first is easy. It seems as if it had to bear the burden of both. Neither a shunt-wound nor a series-wound, nor a compound-wound motor can be used practically on a constant-current circuit to maintain a constant speed with variable load. The ordinary series-wound motor, which is the natural and common form for the constant-current motor, will race away when the load is taken off and increase in speed until it tears apart or strains the armature and ruins the machine. We require some special and very effective device to accomplish the regulation in this constant-current case, and it seems to happen that almost every device that has been thought of has serious difficulties and complications. The ordinary, and what would seem to be the best, solution of this

* Paper read before the American Institute of Electrical Engineers, New York, May 22, 1889.

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problem is to vary the magnetic effect of the field upon the armature directly in proportion to variations in the load. This is effected by cutting out the field-coils, and by other methods which will be described later. But there are difficulties with almost all these plans.

These two cases, which, as already stated, are the commonest and most important which occur, and yet which are so very different in almost every respect, give a general idea of what we have to deal with in motor regulation.

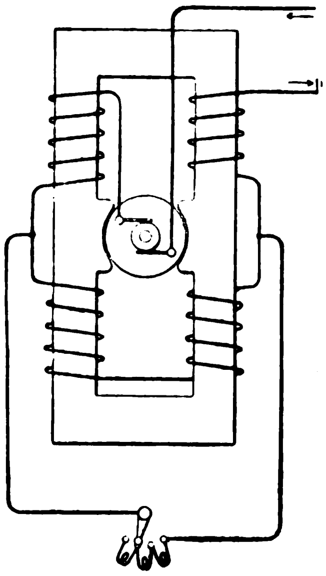

Fig. 7.—Series Motor with variable magnetic shunt.

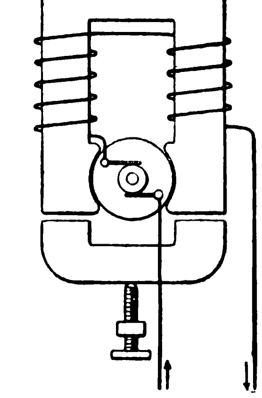

Fig. 8.—Series Motor with variable magnetic short circuit.

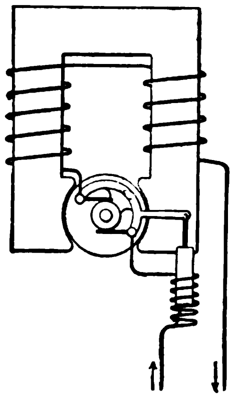

Fig. 9.—Series Motor with automatic device for shifting brushes.

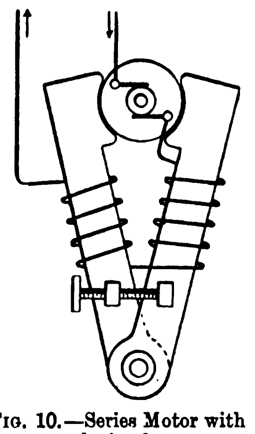

Fig. 10.—Series Motor with device for moving pole pieces apart.

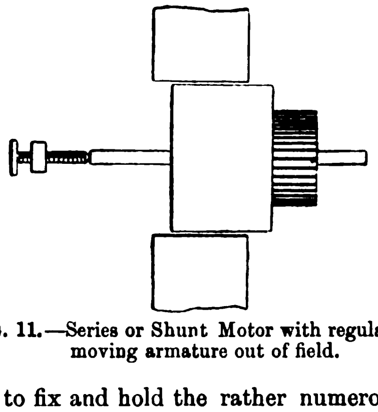

Fig. 11.—Series or Shunt Motor with regulator for moving armature out of field.

In order to fix and hold the rather numerous quantities and conditions that present themselves in connection with motor regulation, a tabular statement of them is given below :

Table I.—*Electric Motor Regulation.*

1. Hand regulation.
   Usually employed for varying the speed.
2. Automatic regulation.
   Usually employed to maintain constant speed, and is effected by
   Centrifugal governors.
   Dynamometric governors.
   Electromagnetic devices.

Principal Methods of Motor Regulation.

1. Shunt-winding. Fig. 1.
2. Differential-winding. Fig. 2.

Varying external resistance in series with

3. Armature.
4. Field. Fig. 1.
5. Both armature and field.

Varying internal resistance of

6. Armature.
7. Field by cutting out coils in series. Fig. 3.
8. Field by cutting out coils in multiple arc. Fig.
9. Field by grouping coils in series or multiple arc
10. Both armature and field. Fig. 5.

Varying shunt in multiple arc with

11. Armature.
12. Field.
13. Both armature and field. Fig. 6.
14. Varying current in separately excited field.
15. Shunting field magnetism. Fig. 7.
16. Short-circuiting field magnetism. Fig. 8.

Varying commutation by

17. Shifting brushes. Fig. 9.
18. Shifting commutator.
19. Shifting magnetic resultant.
20. Moving pole-pieces away from armature. Fig. 10.
21. Moving armature away from pole-pieces. Fig. 11.

Table II.—*List of Possible Cases with Direct Currents.*

P = Difference of potential in volts at terminals of motor.
C = Current in amperes supplied to motor.
S = Speed of armature in revolutions per minute.
L = Load or torque in pounds at 1ft. radius.

Any of these four quantities may be either constant or variable, making the following combinations :

Case.	Constant.	Variable.	Example.
1.	P	C S L	Series-wound motor with variable load on const. pot. cir.
2.	P S	C L	Shunt or comp.-wound motor with variable load on con. pot. cir.
3.	P L	C S	Shunt motor with con. load and var. field resist. on con. pot. cir.
4.	P S L	C	Not practical.
5.	P C	S L	Not likely to occur.
6.	P C S	L	Impossible.
7.	P C L	S	Impossible.
8.	P C S L		Shunt motor with constant load on constant potential circuit.
9.	C	P S L	Shunt motor with var. load on constant-current circuit.
10.	C S	P L	Series motor with speed gov. and var. load on constant-current circuit.
11.	C L	P S	Series on arc const. torque.
12.	C S L	P	Not practical.
13.	S	P C L	Motor with speed gov. and var. load on cir. of var. pot. and cur.
14.	S L	P C	Motor with const. load and speed gov. on. cir. of var. pot. and cur.
15.	L	P C S	Motor with con. load without speed gov. on cir. of var. pot. and cur.
16.		P C S L	Motor with var. load without speed gov. on cir. of var. pot. and cur.

In table I, motor regulation is divided into hand regulation, which, it happens, is almost always used for varying the speed of a motor, by a hand switch, Fig. 1, for example, and automatic regulation, which is almost always used to maintain a constant speed, and which is usually accomplished in one of the three following ways : First, by a centrifugal governor similar to that of the steam-engine, operating a switch or other device, Fig. 3 ; secondly, by a dynamometric governor—*i.e.*, a mechanism through which the load or torque of the motor is transmitted, which may also operate a switch and vary the power of the field by the direct effect of changes in the load ; thirdly, by an electromagnet device, such as a solenoid, through which the current, or a portion of it, is passed, which causes the core of the solenoid to move and operate a switch in accordance with variations in the current, Fig. 9.

The table next gives the principal methods used to regulate motors. These consist of different arrangements and combinations of parts to produce different effects or changes in the working of the motor, and they constitute the means which we have to employ to accomplish a certain object in motor regulation. Method 1 is simple shunt-winding, which consists in exciting the field-magnet with a circuit of comparatively high resistance in multiple arc with the armature (Fig. 1). This maintains a motor at constant speed with varying load on a constant-potential circuit, and does this all by itself, as it were, without any trouble, as already pointed out. The reason for this is that the field,

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being fed with a constant potential, is therefore of constant strength, and a slight variation in speed of the armature, about 5 per cent., will vary the current in it from zero up to its full capacity, and therefore vary its power to an equal extent.

Method 2 is differential winding (Fig. 2), which is a refinement of the first, by which an almost absolutely constant speed—*i.e.*, within one or two per cent.—may be practically maintained. This consists in winding a series-coil of comparatively few turns upon the field-magnets, in addition to the shunt-winding in the previous case, the series-coil being wound in the opposite direction and opposed magnetically to the shunt-coil. The effect of this is to slightly weaken the field magnetism as the load on the armature, and consequently its current, increases. This tends to increase the speed of the armature and counteract its tendency to slow down with increased load, thereby almost entirely eliminating even the small variation of 5 per cent. in speed which occurs in the ordinary shunt-motor. The paradoxical fact that a shunt-motor increases its speed with the weakening of the field-magnet is well known, being due to the lowering of the counter E.M.F., and consequent increase of current in the armature as the field magnetism is reduced in intensity.

In the next three methods the external resistance in series with the armature or field, or both, is varied. Method 3 would be very wasteful, and is hardly allowable in good practice, because it is simply destroying the main current to put resistance in the armature circuit. Method 4, varying the resistance in the field circuit is very much less objectionable, and is very convenient and common (Fig. 3). This mode can be adopted with a very small loss of current, because the field current is only a small part of the total current used in the motor, and the loss of a portion of this small fraction is practically insignificant. Method 5, putting external resistance in series with both the armature and field is open to same objection as case 3, since it throttles and destroys part of the main current.

The next five modes of regulation, 6, 7, 8, 9 and 10, are theoretically more economical than the preceding, because we vary the internal or useful resistance instead of adding external or dead resistance. Method 6, in which the internal resistance of the armature is varied, is very difficult to carry out in practice, simply because it is hard to get at and change the connections of the armature while it is revolving. One of the few ways devised to accomplish this is to wind the armature with two or more circuits connected to a corresponding number of commutators, whereby one or more of these circuits may be used, thus varying the internal resistance and torque. This is clumsy, and practically little better than using two or more separate motors.

Method 7, cutting out the field-coils in series is a very simple and common plan. It is the ordinary way of regulating constant-current or other series-wound motors. This method, or some modification of it, is one according to which the constant-current or "arc" motors of the Baxter, "C. and C." and Excelsior companies are constructed. Method 8, of cutting out field-coils in multiple arc, is shown in Fig. 1, and is especially applicable to shunt-wound motors. The different layers, for example, may be respectively connected to the contact points of a switch and thrown into circuit successively, the innermost layer first, etc., thus obtaining the most economical result.

Method 9, of grouping the field-coils in series or multiple arc produces very great variations in field resistance, and is a combination of the two preceding cases. Like them, it consists in winding the field with separate circuits, which are connected to a switch. This is employed in street car motors to obtain the great variations in resistance and power required of them.

Method 10 is also merely a combination of two or more of the four preceding cases. A simple way of carrying it out is illustrated in Fig. 5, and consists in connecting the armature and field either in series or in multiple arc, by which a great variation in the total internal resistance of the machine is obtained.

The next method, No. 11, is open to the same objection as No. 6, because when the armature is shunted the main current of the machine is affected. This is, however, less objectionable than dead resistance, because in most cases it is better to divert the current than to destroy it.

Method 12, like methods 4 and 7, is a useful and common one, because in shunting the field we are merely handling a very small fraction of the total current.

Method 13, varying a shunt in multiple arc with both armature and field, is wasteful, like No. 11. It was, however, the plan by which the first arc motors were regulated, a variable shunt being placed in the main circuit, and the motor connected to the terminals of the shunt.

The variations in the shunt, of course, throw more or less current through the motor, thereby varying its power as required.

Method 14, varying the current in a separately-excited field, is merely historical, as this class of motors has gone out of use. The plan, however, is a very effective one, because, of course, it is very easy to control the field current when it is produced by a separate source.

Method 15 is shown in Fig. 7, and consists in shunting the field magnetism—*i.e.*, diverting the lines of force from the armature through some other path. In the arrangement shown in Fig. 7, there is a simple series-wound motor with consequent pole field-magnet, and if the coils exciting one magnetic circuit are short-circuited, it is evident that the magnetism produced in the other magnetic circuit will be short-circuited or shunted by the former. The short-circuiting of the coils is effected by the variable shunt, as indicated.

Method 16 is very similar to the preceding, and consists in short-circuiting the field magnetism, and diverting it from the armature by a keeper, which may be moved towards or away from the pole-pieces by means of a screw or other contrivance.

We now come to methods 17, 18, and 19, in which the line of commutation is varied. The first is the well known plan of shifting the brushes. This is very effective and easily carried out, and has, therefore, been used quite extensively; but it has the very serious and almost prohibitory objection that when the brushes are moved from the neutral point they spark very badly. This may be remedied to a slight extent by some heroic plan like blowing out the spark produced. But, as sparking is one of the worst drawbacks of a motor, it hardly seems as if this method of regulation would be permanent.

Methods of regulation which are all right for dynamos may not be allowable in the case of motors, because the former is usually in the hands of skilled men devoted to their care, while motors are often run by ignorant and careless persons.

Method 18, shifting the commutator, is simply another way of doing the same thing as shifting the brushes.

Method 19, shifting the magnetic resultant or direction of lines of force in the armature, may be accomplished by two sets of pole-pieces, the relative magnetic strength of which is varied. This is also open to the same objection as shifting the brushes.

Method 20, shown in Fig. 10, consisting in moving or separating the pole-pieces from the armature, had been used in the Diehl and other motors, but it is rather difficult to carry out mechanically, and introduces a hinge or joint in the magnetic circuit, which is, of course, very undesirable.

Method 21, moving the armature away from the pole-pieces, is very much easier to accomplish mechanically, and has a great many advantages as a means of regulation. Mr. S. S. Wheeler and myself have been working for some time on motors in which this method of regulation is employed, and the results we have obtained have been very satisfactory; in fact, we have found it to be extremely simple, effective, and reliable.

The second table gives a list of the possible cases of motor regulation which may occur with direct or continuous currents. There are four supremely important quantities or conditions in connection with electric motor regulation, viz., potential, current, speed, and load, and it is with reference to one or more of these that practically all motors are designed, built, sold, and used. Motors are always distinguished, both in science and in trade, as constant-potential or constant-current motors; constant or variable speed motors, and con-

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stant variable load motors; hence a classification of motors based upon the constancy or variability of these four factors is very convenient, and at the same time scientifically correct. The second table is made upon this plan, and in it the four quantities are represented by their initial letters, P, C, S, and L, expressed respectively in volts, amperes, revolutions per minute, and torque in pounds at one foot radius, these being the units ordinarily used in practical as well as scientific work. We find that there are in all sixteen different cases, in the first four of which the potential is constant; in the second four the potential and current are both constant, in the third four the current only is constant, and in the fourth four neither the current nor the potential is constant.

Case 1, in which the potential alone is constant, is the case of a series-wound motor, for example, with variable load on a constant-potential circuit. Such a motor would rise in speed when the load was reduced, and *vice versâ*. It would not be at all self-regulating—in fact, it would tend to run at a very high speed with light load, and a very low speed with a heavy load. It is possible to give various other examples, but one is sufficient in most cases. In this case, however, I may say that the ordinary street car motor, fed from a constant-potential circuit, is also an example of case 1, the current being controlled by varying the external or internal resistance, according to one of the methods given in the first table.

(To be continued.)

PHYSICAL SOCIETY.—June 8.

Prof. AYRTON, F.R.S., Vice-President in the Chair.

Dr. Bond and Mr. Bretton were elected members, and the following communications were made:

A "Photograph of Lightning Flashes" was exhibited and described by Dr. Hoffert. The photograph was obtained during the storm on the 6th inst. whilst the camera was being waved about in the hands, and shows three similar and parallel flashes, thus proving that successive sparks in multiple flashes may traverse the same path and may be separated by appreciable intervals of time. The supposed primary spark is intersected by numerous tributary ones spreading out on both sides; the second spark one tributary, and the third none. Faint bands of light pass across the plate parallel to the direction of motion, and these prove that some residual illumination exists during the intervals between the successive flashes. Evidence of a dark flash is also presented by the plate.

Prof. Herschel, who had taken photographs during the same storm, referred to the fluttering appearance of the flashes, and on their long duration—in many cases the time was sufficient to allow him to direct the camera towards the flash and make a successful exposure. He had also observed multiple flashes with the unaided eye, and on waving his hand about he had sometimes noticed about a dozen distinct images of it during one discharge.

Mr. Gregory said that he watched the storm along with two others, and they could seldom agree as to the shape of the flashes, or on their simple or multiple character. The want of agreement as to multiplicity he thought might be caused by their eyes being directed towards different parts of the sky when a multiple flash occurred; the one who happened to be looking towards the flash might be conscious of only one impression, whereas the others in directing their eyes would receive the flashes on different parts of the retina. In some cases as many as three distinct flashes (occurring at intervals of about ten seconds) traversed the same path, and a number of the discharges presented a beaded or striated appearance. The beads seemed to remain after the main flash had faded, and this might account for the beads shown in Dr. Hoffert's photograph.

Mr. C. V. Boys, in referring to multiple flashes, said that although his statements made in the discussion of Mr. Whipple's paper on April 13th were not readily accepted, yet no one who watched the recent storm could doubt their existence.

Prof. S. P. Thompson thought the order of the flashes on the photograph may have been the reverse of that supposed, for he observed that the bands of light extended on both sides of the (so-called) primary flash, whereas the outside of the third flash was quite dark.

Mr. E. W. Smith noticed many cases of "sympathetic discharge," in which a flash in the north seemed to precipitate another in the N.W. within a few seconds, and in this he was corroborated by **Mr. Gregory**, who viewed the storm from a different locality.

Mr. C. V. Burton thought the heating of the air by the first spark might give rise to the tributary sparks in subsequent ones.

Mr. A. W. Ward mentioned a long flash observed at Cambridge, which passed from the zenith and struck some farm building at a distance, and he was particularly impressed by the considerable time occupied in its progress.

"On the Methods of Suppressing Sparking in Electromagnets," by Prof. S. P. THOMPSON, D.Sc. The object of this paper is to classify the methods which have been suggested, and to draw attention to a novel method of some importance. The classification is as follows: (1) *Mechanical Devices.* (*a*) Simple snap switch. (*b*) Break in magnetic field. (*c*) Break under liquid. (*d*) Wiping break (asbestos, etc., brushes). (*e*) Blow out. *Electrical Devices.* (A) Use of condensers, (*a*) placed across gap; and (*b*) across terminal of magnet. (B) Mutual induction protectors, (*a*) copper sheet around core; and (*b*) layers of coil between winding. (C) Short-circuit working. (D) Differential winding. (E) High-resistance shunt (non-inductive). (F) Voltameter, or liquid resistance across gap. (G) Multiple wire arrangement of Mr. Langdon Davies. (H) Electromagnet with two bobbins in series or parallel. The merits and demerits of the different methods are indicated. The multiple wire arrangement used by Mr. Langdon Davies in his harmonic telegraph consists in winding each layer separately, and uniting all in parallel. The effect of this is to make the time-constants of the layers different, and on breaking the circuit the energy is spent in mutual discharges.

"A Shunt Transformer," by MR. E. W. SMITH. Two conductors, A and B, of equal impedance are placed in series between alternate-current mains, and the same mains are connected through two incandescent lamps in series. The conductor A has great resistance, and B has large self-induction, and when their junction is joined to that of the two lamps, both lamps become brighter and the main current is reduced. These phenomena were shown before the society. Since A may consist of lamps, and B may be a choking coil, the arrangement will serve to increase the P.D. between the terminals of the lamps without wasting much energy. Experiments of a similar nature has been made on a Mordey transformer, wound with three equal coils. One coil was used as primary, and the other two as separate secondaries, their respective circuits consisting of lamps and an alternate-current motor. Under these conditions the arithmetical run of the mean secondary currents exceeded the primary current by 14 per cent., the secondary volts were 8 per cent. less than the primary. All these experiments strikingly illustrate the effects of acceleration and lag in alternate-current circuits, and (as was pointed out by the author) show that meters registering "ampere-hours" merely may give readings differing greatly from the numbers representing the energy used.

COMPANIES' MEETINGS.

SUBMARINE TELEGRAPH COMPANY.

An extraordinary general meeting of this Company was held on Wednesday at the offices, Throgmorton-avenue, Sir Julian Goldsmid M.P., in the chair, to consider the confirmation of the resolution passed at the recent meeting for winding up the Company voluntarily under the Companies Acts, 1862 and 1867, and for appointing Sir J. Goldsmid, the Hon. Henry R. Brand, and Mr. S. M. Clare liquidators.

The **Chairman** said he believed that when they had gone through that meeting they would have done all that the Post Office had demanded of them. They had realised the reserve fund, obtaining for their investments about £28,000 in excess of their original cost price. This realisation had enabled them to make a distribution of assets among the shareholders, who had received their warrants for 75 per cent. of the capital of the Company. They had now to receive from the Post Office the money for the purchase of the cables, the house where they were then met, etc., and they had also to receive the money which the Paris and New York Company had to pay them for their interest in the Déolen cable. There would then be only one matter to complete—that was, to come to some arrangement with the Anglo-American Company as to the Salcombe cable. He feared that that matter would take the longest time to arrange. The liquidators would, however, do all they could to press forward the settlement. He concluded by moving the confirmation of the resolutions above mentioned.

The **Hon. A Ponsonby** seconded the motion, which was adopted.

Mr. Carmichael then moved a resolution to the effect that the remuneration of the liquidators be settled when they presented the account of the liquidation.

Mr. King seconded the motion, and expressed a hope that the expenses of the liquidators would be made to bear as lightly as possible on the shareholders. He considered that the Government had squeezed the Company most unmercifully.

The **Chairman** assured the shareholders that the liquidators would require no undue payment. In reply to other questions, he stated that among the assets of the liquidation would be their share of the earnings for the first three months of this year. He believed the shareholders would receive something over par—between 105 and 110; but until they had come to a settlement in regard to the Salcombe cable and the expenses he could not say what they would get. As soon as the liquidators had the money in hand to make a further considerable distribution they would do so.

The resolution was then unanimously passed.

A vote of thanks to the Chairman terminated the meeting.

GERMAN UNION TELEGRAPH COMPANY.

Sir James Anderson presided on Monday at Winchester House, Old Broad-street, over a general meeting of the members of the German Union Telegraph and Trust Company, Limited.

The circular of the liquidators intimated that a final payment of £2. 4s. per share would be made in exchange for their share certificates (making a total return of £9. 10s. per share in respect of the £10 held in the trust).

The **Chairman** said that the shareholders were naturally disappointed at not receiving a larger sum of money for their shares, or such a sum as was held out to them as probable a year ago. The

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irony of fate had, however, been very hard upon them—so much so that since they sold the cable to the Government, and before the latter took its working over, there were two breaks which cost £13,000, or £1,400 less than the cost of the repairs of the whole previous 17 years. The liquidators had distributed all the money they had received, and thus would end the German Union Company, which had been very useful to the German Government and the public. He was bound to say that the German Government had used them better than their own Government had used the Submarine Company; and if the cables were going to fall into the hands of the Governments, he hoped they would be treated in the same way as the German Government had acted towards this Company, or perhaps a little better even. It was with great regret on his own pa:t, and on the part of the Directors, that he proposed the following resolution: "That the liquidators' account submitted to this meeting, showing the manner in which the winding up of the Company has been conducted, and its property disposed of, be received and adopted."

Count Reichenbach seconded the resolution, which was carried unanimously; as was also the following resolution: "That the books, accounts, and documents of the Company, and of the liquidators thereof, be retained by the liquidators, with authority to them to destroy the same after the expiration of one year from the dissolution of the Company."

A vote of thanks to the liquidators closed the meeting.

NEW COMPANIES REGISTERED.

Electricity Supply Corporation, Limited.—Registered by Sydney Morse, 4, Fenchurch-avenue, E.C., with a capital of £100,000, in £10 shares (100 of which are founders' shares). Object: to apply for, obtain, undertake, and carry out a provisional order for the supply of electric light and power within the parish of St. Martin's-in-the-Fields, in the county of Middlesex, and also generally any contracts, acts, provisional orders, licenses, decrees, and concessions for, or in relation to, the supply of electricity in Great Britain or elsewhere; to carry on the business of electrical engineers, electricians, engineers, and contractors, manufacturers of electrical and other apparatus, etc. The first subscribers are:

	Ordinary shares.
J. Irving Courtenay, 1, Elm-court, Temple, E.C.	1
J. Barclay, 5, Clarendon-place, Hyde-park-gardens	1
Sir D. Cooper, M.P., 6, De Vere-gardens, S.W.	1
L. W. Novelli, Oxford and Cambridge Club, S.W.	1
J. Meston, 75, Union-street, Aberdeen	1
F. D. Finlay, 70, Gloucester-place, W.	1
F. King, 65, Chelverton-road, Putney	1

There shall be not less than than five nor more than 10 Directors. Qualification: 50 shares, the first to be appointed by the subscribers to the memorandum of association. Remuneration to be determined in general meeting.

Electricity Supply Company for Spain, Limited.—Registered by Slaughter and May, 18, Austinfriars, E.C., with a capital of £100,000 in £5 shares, of which 100 are founders' shares and 19,900 ordinary shares. Object: to form centres in any towns and districts in the Kingdom of Spain, at which electric power may be generated or accumulated, and from which the same may be distributed by means of wires or other conductors of electricity for the purpose of lighting private houses or street lighting, or the lighting of public buildings, shops, factories or works, or for the purpose of giving motive power or heating in all such places. The first subscribers are:

	Shares.
R. Hammond, 117, Bishopsgate-street Within, E.C.	1
W. May, 18, Austinfriars	1
H. E. Warner, Beechcroft, Streatham Common	1
H. Mann, 12, Woburn-place, W.C.	1
W. A. Mann, 7, St. Helen's-gardens, North Kensington, W.	1
T. E. Towerson, F.C.S., 1, Portland-road, Finsbury Park	1
H. St. J. Winkworth, 22, Clareville-grove, South Kensington	1

There shall not less than three nor more than seven Directors. The first to be appointed by the subscribers to the memorandum of association. Qualification: £250 stock. Remuneration: £500 per annum, together with one-tenth of the net profits after 7 per cent. dividend, divisible as they determine.

Elmore's Foreign and Colonial Patent Copper Depositing Company, Limited.—Registered by Newman, Hays, and Co., 31, Abchurch-lane, E.C., with a capital of £120,000, in 15,000 priority shares of £5 each, and 9,000 founders' shares of £5 each. Object: to purchase, take over, resell, and work the whole or any of the foreign or colonial patents, and provisional specifications for foreign or colonial patents of F. E. and A. S. Elmore, and all improvements thereunder relating to the treatment and electrical deposition of copper and other metals, and for the manufacture of all kinds of metal articles. The first subscribers are:

	Shares.
Sir J. H. Morris, K.C.S.I., 88, Queen's-gate, S.W.	50
J. M'Farlan, Invermay, Wimbledon	50
E. Carron, Rydal, Surbiton-hill-park	50
F. L. Rawson, 11, Queen Victoria-street, E.C.	1,150
J. H. Ward, 11, Queen Victoria-street, E.C.	1
R. Jones, Lily Lodge, Hampstead	1
W. Rawson, 68, Cornwall-gardens, S.W.	1

There shall not be less than three nor more than 11 directors. Qualification: 50 shares; the first to be appointed by the subscribers to the memorandum of association. Remuneration: £1,500 until the board exceeds seven, when it shall be £2,000, with 5 per cent. of net profits after 10 per cent. dividend.

CITY NOTES.

West African Telegraph Company.—A dividend of 5s. per share is announced by the Directors of this Company, in respect of the year ended December 31 last.

Mining and General Electric Lamp Company, Limited.—The works address of the above Company is now at 64, Millbank-street, Westminster, to which place goods or communications should be sent.

West India and Panama Telegraph Company.—The traffic receipts of this Company for the half-month ended June 15th are £3,157, as compared with £2,971 in the corresponding period of 1888.

South of England Telephone Company, Limited.—In the report of this Company for the year ended April 30, the Directors recommend a distribution of 1 per cent., leaving a balance of £627 to be carried forward.

Eastern and South African Telegraph Company, Limited.—This Company notify that the coupons, due July 1 next, on their 5 per cent. mortgage debentures will be paid on and after that date at the banking-house of Messrs. Barclay, Bevan, and Co., 54, Lombard-street, E.C.

PROVISIONAL PATENTS, 1889.

JUNE 11.

9589. **Improvements in electric signals for indicating the direction and speed of revolution of engine shafts.** James Clark Ricketson, 52, Chancery-lane, London. (Complete specification.)

9659. **Improvements in and connected with electric batteries.** Arthur Harry Norman, 4, South-street, Finsbury, London.

JUNE 12.

9667. **Improvements in apparatus for the generation of electricity.** George Wilkinson, 2, Princes-mansions, Victoria-street, Westminster.

9681. **Improvements in electrical storage or secondary batteries.** Roger Tatham, 4, Clayton-square, Liverpool.

9713. **Improvements in electric conductors.** James Grieve Lorrain, Norfolk House, Norfolk-street, Strand. (La Société d'Exploitation des Cables Electriques Système Berthoud, Borel et Cie., Switzerland.)

JUNE 13.

9743. **Improvements in field magnets of dynamos and electro motors.** Charles Richardson, 74, Barrett-street, Brooks Bar, Manchester.

9745. **Improvements in or relating to dynamo-electric machines.** Wilfrid Swanwick Boult, 24, King's Mount, Birkenhead, Cheshire.

JUNE 15.

9828. **Improvements in secondary voltaic batteries.** William Joseph Starkey Barber-Starkey, 70, Market-street, Manchester.

SPECIFICATIONS PUBLISHED.

1888.

8525. **Electric trembling bells.** Rawson and John. 8d.

10092. **Supplying electricity to tramcars, &c.** Lineff. 11d.

10654. **Electric arc lamps.** Mortimer and Holloway. 8d.

11749. **Electric lamps.** Sellon. 8d.

12858. **Distributing electric energy.** Zipernowsky and Deri. 8d.

1889.

3881. **Regulating electric currents.** Balet. 1s. 3d.

4960. **Administering electricity.** Lawrance. 8d.

5912. **Suspending electric conductors.** Van Depoele. 8d.

6804. **Telephone transmitters.** Lake (Straton.) 8d.

6865. **Secondary batteries.** Heyl. 4d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	4½
12 Feb.	2/0	— fully paid	5	3¾
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	19½
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	¼
......	...	London Electric Supply ...	5	3¾
......	...	Swan United	3½	3¼
12 July	12/0	Telegraph Construction ...	12	42½
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15

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NOTES.

Llandudno.—The pier and pavilion at Llandudno are now lighted by electric light.

Conversazione.—The conversazione of the Society of Arts will take place to-night (Friday), at the South Kensington Museum.

Dundee.—The order for the electric lighting of the Albert Hall, Dundee, has been placed with Messrs. Paterson and Cooper.

Isle of Man Telegraph.—In the House of Commons on Thursday, June 20th, the Telegraphs (Isle of Man) Bill was passed through Committee.

Cuba.—The Thomson-Houston Company have put up a fine plant in Cuba for public lighting, consisting of 1,000 incandescents and 100 arcs.

Society of Arts Medals.—The silver medal of the Society of Arts has been awarded to Prof. Silvanus P. Thompson for his paper on "Arc Lamps and their Mechanism."

Sentence for Electric Sugar Frauds.—Howard was sentenced at Washington, on June 21, to nine years and eight months in a State prison for complicity in the electric sugar frauds.

Munich.—The electric light is very much appreciated in Munich. There are now 116 installations, fitted by nine firms, comprising a total of 588 arcs and 23,231 incandescent lamps in the town.

Electric Light in Mines.—The Llay Hall Colliery, Gwersyllt, is now fitted with electric light. There are 65 incandescent lamps in use, of 16 and 32 c.p., lighting the pithead, yard, crossings, offices, and workshops.

Electrical Exhibition.—A correspondent to the *Birmingham Daily Post* points out that sections Q to V in the exhibition at Bingley Hall will be at a disadvantage from want of sufficient access, unless the transept is continued into that avenue.

Errata.—Two somewhat curious errors crept into our last number. First we referred to Prof. Houston instead of Prof. E. Thomson as being at Paris; and gave the motto of the R. A. S. as "experience" instead of "Science with Practice."

New Cables.—The manufacture of the new Halifax-Bermuda cable is now in progress at Henley's Telegraph Works Company, North Woolwich. A Danish and a West Indian cable manufactured by the same firm, are also nearly ready for shipment.

The Column Printing Telegraph.—The Exchange Telegraph Company, Limited, notify that they are the sole proprietors of patents for column printing instruments, and will take legal proceedings against all persons using or selling instruments which are infringements of the same.

River Party.—It is proposed to hold a river party in connection with the Old Student's Association on the Thames above Sunbury, on Saturday afternoon, July 13. Inclusive tickets will be about five shillings, and ladies are specially invited. Further details of the Hon. Sec., 14, Garfield-road, Lavender Hill, S.W.

Edinburgh.—At the last meeting of the Edinburgh and Leith Gas Commissioners, a motion was notified: "That it be remitted to the Works Committee to consider and report as to what attitude the commissioners should assume towards electric light companies proposing to supply electric light and power for the citizens of Edinburgh."

Palais des Machines.—The heat from the steam-pipes and engines in the machinery gallery at the Paris Exhibition is a very serious drawback, especially as the weather now tends to become hotter. M. Vigreux proposes to instal large ventilating fans driven by electricity on a system similar to that adopted in the Hotel de Ville at Paris.

Paris Exhibition.—The proposition to permanently preserve the buildings at the Paris Exhibition has met with favour amongst the authorities, and the question having come before the Municipal Council on the 18th June, it was decided "that the prefectoral administration be invited to negotiate with the State for the preservation of the buildings of the Exposition of 1889 situated in the Champs de Mars."

Reading.—The Thomson-Houston arc lamps in Reading have awakened the gas company to action, and they have approached the Corporation with the proposition to supply more light to the streets. The Town Council, however, appear to be in favour of electric light. The majority are willing to enter into a five years' contract, under Messrs Laing, Wharton, and Down, for 30 arc lamps of 1,400 c.p., at £27 per annum, to be kept lighted all night.

Electricity on the Metropolitan Railway.—The Committee of the House of Lords on unopposed Bills passed on Monday last the Bill of the Metropolitan Railway Company, which, among other powers, authorises the company to use "electricity on their railways or any mechanical or other power other than steam power, either in addition to or in substitution for steam power." This Bill has already been sanctioned by the House of Commons.

Cable Repairing.—The India Rubber, Gutta Percha, and Telegraph Works Company has just received a telegram from Mr. Matthew Hamilton Gray, engineer in charge, saying that the cable steamer "Silvertown" had successfully removed three faults from the cables connecting Dakar (Senegal) with Teneriffe without interrupting the working of the lines. As one of these faults was in the neighbourhood of Teneriffe and the other two near Senegal, some 800 nautical miles southward, and the work was carried out in about 10 days, those engaged in the operations are to be congratulated on their success. The "Silvertown" is expected to arrive in London on 5th prox.

The Electric Carriage.—After the parade of the cattle before their Royal Highnesses the Prince and Princess of Wales and the Royal Family, at the Royal Agricultural Show at Windsor on Wednesday, His Royal Highness, being interested, asked that the electric carriage of Messrs. Immisch and Co. might be brought before him by a member of the firm, who explained the principle and action of this mode of locomotion. Their Royal Highnesses appeared greatly pleased with the simplicity of the details, and at the ease with which the carriage is driven and guided, the motive force being supplied to the accumulators from one of the Immisch electric launch charging stations now lying in the Thames off Windsor.

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Electric Light in Pall Mall.—At a meeting of the St. James's Vestry, on Thursday, June 20th, the Lighting Committee recommended: "That Messrs. Trinders and Co. be informed, in reply to their notice of the intention of the St. James's and Pall Mall Electric Light Company to apply for a provisional order, under the Electric Lighting Acts, in the next session of Parliament, that the Vestry are not prepared to assent to the said company applying for a provisional order until they have acquired a generating station in the northern part of the parish, or are otherwise in a position to supply electricity throughout the whole parish." Mr. W. Jenkins moved the adoption of this recommendation, which was agreed to.

Plante's Researches.—The news of the death of M. Gaston Planté has been received throughout the country with feelings of the deepest regret. It is strange that although his genius and ability were universally recognised, so little is known of his very able book entitled "The Storage of Electrical Energy," which contains a description of all his experiments with voltaic batteries, which finally led to the well-known form of Planté cell. Besides his experiments with all the common metals, as voltaic couples, there are extremely interesting articles on the discharge of high-tension currents and globular lightning. It is doubtful if this latter subject has ever before been treated so completely, or with so many well-authenticated instances, which stands beyond dispute. The book cannot be too strongly recommended to all who have to do with secondary batteries, as it contains notes by the original inventor on the practical management of accumulators, and explains all the small but important difficulties which are so often met with, but which may be easily remedied and avoided by a little knowledge of their theory.

A Cheap Electric Current Regulator.—The *Scientific American* describes a cheap instrument, invented by Frank J. Crouch, of Eugene City, Oregon, for regulating electric lights, so that they can be turned up and down, as with gas or oil. A vessel is employed containing a saline or other chemical solution, and in connection therewith are diverging conducting arms connected in circuit with the main line and insulated, a central arm being adapted to be lowered into the solution to any desired depth, the brilliancy of the light being decreased or increased as the central rod is raised or lowered. A rack enables the plunges to be moved up or down. A shunt circuit connects the wires of the system, this circuit having a resistance coil made to balance the lamps used on the circuit, and the coil having a switch, to cut off communication between the coil and the shunt circuit. It is said that an instrument containing only three gallons of the liquid will readily regulate 80 lamps of 30 c.p. each, and it is stated that such instruments have been used for more than a year past, with great satisfaction, to theatres and elsewhere.

The London Electric Supply Company's Mains. The Electric Lighting Committee of the Rotherhithe Vestry reported that Union-road and Lower-road had been scheduled as the thoroughfares in the parish within which the London Electric Supply Corporation were to lay mains within two years, and that £1,000 had been deposited.—At the St. Olave's Board of Works, the clerk reported that the Board of Trade had scheduled Tooley-street, Duke-street, Mill-lane, and a portion of Shad Thames as the streets in which the electric light mains must be laid within two years, and that the company had deposited £1,000.—At the St. Saviour's Vestry, the Paving and General Purposes Committee reported that they had considered the letter from the Board of Trade, requesting to be provided with a list of streets in which, in the opinion of the Board, the London Electric Supply Corporation should be compelled to lay mains within a specified time, and had named the following—viz., Borough High-street, Southwark-bridge-road, Blackfriars-road, and Southwark-street. After discussion, the recommendation was adopted.

Juries at Paris.—The name of M. Marcel Deprez has been added to the members of the jury on electrical exhibits at the Paris Exhibition. The names of the members for foreign sections are: Messrs. Preece and Aylmer (England), Rousseau and Gody (Belgium), Turettini (Switzerland), Abdank (United States), and Hering (Russia). The officers are M. Mascart, president; Preece, vice-president; Potier, general reporter; Turrettini, secretary. The jury is divided into four sections: 1. Machines, transformers, instruments—MM. Fribourg, Hering, Potier, Sciama, Turrettini. 2. Telegraphy, telephony, signals, cables, wires—MM. Aylmer, Marcel Deprez, Jossoulin, Preece, Trottin. 3. Lighting, arcs, fittings—MM. Huet, Postel-Vinay, Rau, Rousseau, Sautter. 4. Electro-chemistry batteries, accumulators, bells, various—MM. Abdank, H. Fontaine, Gody, Mascart, Sebert. The final awards of the juries will take the following forms: 1, grand prize; 2, silver medal; 3, bronze medal; 4, honourable mention; 5, recommendations. The judgments will be based, as far as possible, on the conception of the idea, originality, and ingenuity of construction; construction—character of work and finish of detail; efficiency—electrical or mechanical; industrial value—cost price and maintenance.

Paddington and the County Council.—At the meeting of the Paddington Vestry on June 18, Mr. Mark H. Judge moved the following resolutions, which were agreed to with two dissentients: "That the Vestry of Paddington having considered the letter of the London County Council of June 5, 1889, addressed to the Board of Trade, on the subject of electric lighting, takes the strongest exception to the proposals therein made for transferring the control and purchase of electric lighting in the metropolis from the City Corporation, the Vestries, and the District Boards to the County Council, and this for the reasons which were detailed." "That this Vestry do place on record its opinion that the County Council has exceeded its functions in agreeing to proposals for interfering with the powers of the metropolitan representative governing bodies without first giving them an opportunity of considering such proposals." "That the foregoing statement of objections be forwarded to the Board of Trade, the County Council, and the other representative governing bodies of the metropolis, and the members of the County Council for Paddington." "And that the City Corporation, the Vestries, and the District Boards be asked to inform the Board of Trade and the County Council of their views on the proposals referred to."

The Proposed Electrical Exhibition in Edinburgh.—The first public meeting of the promoters of the Electrical Engineering and Inventors' Exhibition, which it is proposed to hold in Edinburgh next year, took place last Friday. Sir Thomas Clark, Bart., presided. The Chairman moved a resolution remitting the matter to an executive committee to carry out the scheme, and to report

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progress to a future meeting of the promoters, which was adopted. The chairman said he hoped they would succeed in getting the project into proper shape. There could be no doubt that such an exhibition would be very useful, for they could not conceal from themselves the fact that electricity was to be a very important force in the future as it had to an extent been in the past. Mr. Hall Blyth, in seconding, said he thought a much nearer site than that proposed at Gorgie should be obtained. Mr. A. R. Bennett expressed the view that the proposed site possessed exceptional advantages. It was centrally situated for the railways and tramways, while the Union Canal would afford a means of illustrating water power. Mr. Hall Blyth said the site would be the life or death of the exhibition, and the question should be remitted to the executive committee to consider very carefully. This was agreed to, and the proceedings terminated.

Glasgow.—A special meeting of the Town Council of Glasgow was held on Monday to consider a recommendation of the Gas Committee as to electric lighting. The committee reported the receipt of a notice on behalf of Messrs. Muir, Mavor, and Coulson, Limited, of their intention to apply for an electric lighting order applicable to Glasgow. The committee agree to recommend that notices should be given, before the 1st prox., by the Lord Provost, magistrates, and Council as such, and also as police authorities and as gas trustees, of their intention, either conjunctly and severally, or one or other of them, to apply for a provisional order to supply electricity for public and private purposes within the area comprised within the municipal boundaries of the city. It was pointed out that for some years very little had been done by Corporations in regard to electric lighting; but owing to the adoption of the Electric Lighting Acts, they were becoming more active. Many large towns in England had been in the same position as Glasgow, having allowed private companies to start without having Parliamentary powers, who were now coming forward and applying for provisional orders. It was asked if, in the event of the provisional order being obtained, it would be actually carried out, or would it be used merely to block the way when other parties were applying? Mr. Ure pointed out that they could not possibly obtain this provisional order without giving guarantees that they would carry it out. The recommendation of the committee was then adopted unanimously.

London County Council.—The London County Council held their first ordinary meeting after the Whitsuntide recess on Tuesday afternoon, in the Guildhall Council Chamber, under the presidency of the Earl of Rosebery. The Chairman informed the Council that a letter had been received from the Board of Trade thanking the Council for their kindness, and the assistance it had given in the matter of electric lighting, and sending a copy of a model order proposed to be followed in the case of all the electric lighting applications now before the Board of Trade. The matter would be reported by the Highways Committee, probably at the next meeting of the Council. The Board of Trade stated that if the Council desired to bring any points in the order under the notice of the Board, the Board would be glad to receive representatives of the Council and to confer with them on the subject. Perhaps the Council would authorise the Highways Committee if it should think necessary to depute representatives to confer with the Board of Trade, and to suggest, on behalf of the Council, any alterations they might think desirable. The Chairman's suggestion was adopted. At the meeting on Wednesday, the Highways Committee reported that they have directed the letter from the Board of Trade, dated June 13, to be printed, and a copy to be sent to each member of the Council. The model provisional order referred to therein has been considered by the committee, with the assistance of the Council's officers and the Parliamentary agent; and, as the committee deemed some amendments desirable, they have, under the authority given to them on the 18th inst., requested their chairman and Mr. Benn, one of the members of the committee, to confer with the Board of Trade with a view to the amendments being made in the order.

Reduction in Incandescent Lamps.—The Edison Swan Company notify us that on and after July 1st, an important alteration in the tariff of charges for incandescent lamps will take place. The retirement of the Edison-Swan Company from the field of installations, and their devotion solely to incandescent lamps, instruments, and fittings, is not unproductive of result in meeting the requirements of the trade, and we only echo the widespread feeling of satisfaction in welcoming this step in the cheapening of the electric light. In view of the general interest to electrical engineers of such a reduction, we have no hesitation in printing the tariff *in extenso*.

Edison Lamps.

Nominal c.p.	E.M.F.	Tariff.
8	48 to 55 volts	3s. 9d.
10	89 „ 105 „	3s. 9d.
16	89 „ 105 „	3s. 9d.
32	89 „ 105 „	4s. 3d.
50	89 „ 105 „	5s. 3d.

Edison-Swan Lamps.

Nominal c.p. Miniature and Surgical Lamps.	E.M.F. in volts. E.M.F. to order.	Tariff.
1	3 to 8	3s. 9d.
2½	5 „ 8	3s. 9d.
2½	9 „ 25	3s. 9d.
5	10 „ 35	3s. 9d.
8	15 „ 25	3s. 9d.
8	26 „ 55	3s. 9d.
16	30 „ 105	3s. 9d.
25	45 „ 105	4s. 0d.
32	55 „ 105	4s. 0d.
50	80 „ 105	5s. 0d.
100	80 „ 105	7s. 6d.
200	80 „ 105	10s. 0d.
300	80 „ 105	12s. 6d.
500	80 „ 105	17s. 6d.
1000	80 „ 105	30s. 0d.

Lamps not specified above, or which in any way vary from the standard lamps, are to be charged at a higher rate than those above stated. We understand that a new and complete lamp list is in preparation.

Electricity in China.—The news reaches us that a telephone has been put up at the palace of the "Seventh Prince." This is encouraging news from the capital of China, though telephones are not new to Peking, as several short lines have been set up experimentally within the past seven years. They have even been used at the Great Wall of China (the very existence of which wall was disputed not long ago), as well as in the Buddhist temple of the Azure Cloud, some few leagues to the north of the capital. The fact that the telephone is making its way into the palaces constitutes a distinct step in advance, and it is to be hoped they will speedily find favour in the eyes of the *literati*; among the mercantile population of the Southern ports they have long been accepted as useful aids to commerce. Electric lighting is likely to have a grand

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future in Hong Kong now that regularity of supply can be depended upon, and before long the system is certain to spread to all the open ports. It is matter for regret that the uncertainty and oft-repeated failures which attended the earlier installations gave rise to so much delay, for Chinese merchants are always willing to embark capital in any undertaking which can be made to pay a dividend, when they are not interfered with by the mandarin element. We venture to say that those who knew China 20 years ago are now agreeably surprised to find our Western inventions have begun to take root even to the trifling extent already witnessed, for, as a rule, the progress made, though slow, is sure. For all that, we should like to see a little more life put into affairs out there, for we have proof that vital changes may be rapidly effected, without danger to the country or the individual, when we turn to China's enterprising neighbours, the Japanese, regarding whom there were such dismal prophecies a few years ago. It was freely asserted then that Japan was going ahead at a pace which could not last, but the change, stupendous though it undoubtedly was, has been permanent and beneficial in the highest degree, and has resulted in the development of large markets for English goods in that country.

Royal Meteorological Society.—At the last meeting of this society, held on Wednesday, the 19th inst., Dr. W. Marcet, F.R.S., president, in the chair, Mr. W. Marriott gave a very graphic and interesting account of the recent thunderstorms which have prevailed over this country. On Sunday, June 2, a thunderstorm passed across the country in a northerly direction from Wiltshire about 3 a.m., and reaching Edinburgh by 10.44. It travelled at the rate of about 50 miles an hour. It is possible that this storm travelled still further north, and reached Kirkwall at 3.37 p.m. A severe thunderstorm prevailed over the neighbourhood of the Tweed between 11 a.m. and noon, and was accompanied by hail of very large size, some of the stones being five inches in circumference. A very destructive storm occurred over the whole of the North-West of England and South of Scotland during the afternoon. Much damage was caused by lightning, and very large hail fell over an extensive area. Some of the hailstones measured seven inches in circumference, and weighed seven ounces. During the night of the same day a severe thunderstorm prevailed over Norfolk, which was also accompanied by very large hailstones, some of which were five to six inches in circumference. On Thursday, the 6th, thunderstorms prevailed during the afternoon over the whole of the South-East of England; that which passed over the metropolis about nine o'clock was remarkable for the brilliant and continuous display of lightning. During the same night, and in the early morning of the following day, a very destructive storm prevailed over the Eastern Counties, much damage being done by the lightning in the north-west of Norfolk. Severe hailstorms occurred between 2 and 3 a.m. both at Margate and Ipswich. During the afternoon of the 7th, destructive thunderstorms prevailed over the whole of the Southern Counties, much damage being done by lightning, while at Tunbridge Wells there was a most remarkable hailstorm—one of the hailstones, which was weighed, was actually half a pound in weight. An interesting collection of over 40 photographs of lightning, taken during the storm on June 6, was also exhibited to the meeting. In addition to the sinuous, ribbon, and meandering flashes of lightning, several photographs showed knotted, multiple, and dark flashes.

Leeds Proposed Central Station.—The following are additional details of the report of the Electric Lighting Committee of the Leeds Corporation, to which we alluded last week. The report begins by reminding the members of the Council that at its meeting held in May, 1883, the sum of £10,000 was granted to the committee "to carry out an experimental system of electric lighting within and about such portions of the municipal buildings as the committee may consider desirable," and then explains at some length how the money has been expended, and with what success. The total expense incurred up to the present has been £10,233. 18s. 11d., or practically the amount originally voted. Continuing, the report goes on to say that whilst the Council's instructions to the committee were limited to making experiments in and about the Town Hall, in compliance with a generally expressed wish, it has deemed it its duty to go into the question of lighting with electricity the centre of the town. Until recently distance has precluded lighting large areas from central stations, but this difficulty has been removed by an improvement which enables high potentials and small mains to be used in place of low potentials and large mains. To secure the best possible method the committee has visited various towns where the electric light is used, and then sought information from the tenants of shops bounded by Albion-street, Boar-lane, Briggate, and Commercial-street, to ascertain the disposition of the tradespeople in regard to an electric light supply. The desire to have the electric light was almost unanimous. The committee then mapped out the district bounded by Vicar-lane, New Market-street, Duncan-street, Briggate down to the Bridge, Boar-lane to the New Station, Park-row, Guildford-street, Upperhead-row, New Briggate, and North-street to Vicar-lane; and, after ascertaining the exact number of lamps which would be required in a given area, and using this as a basis, it was found that the number of public and private lamps required for lighting this district would be about 37,500. The piece of land known as "The Midden" has been fixed upon for the central station, and tenders show that the machinery and other plant required will cost in all about £58,000. To supply private residences, however, would cost an additional £10,000, making in all £68,000. The committee point out, however, that whilst the latter amount would be required to carry out the whole of the scheme described, the electric lighting station would consist of a unit or initial plant, which might be multiplied from time to time as the demand for the light increases. For this reason, they would not advise this central lighting installation for Leeds to be, in the first place, larger than would involve an expenditure of £25,000. As to the question of cost, the committee is of opinion than an incandescent 10-c.p. lamp can, after paying for depreciation and interest, but not making a profit, be run for one-eighth of a penny per lamp per hour. Comparing this with the present price of gas in Leeds, electric lighting can be supplied at 20 per cent. above that price; but as the customers would have in addition to pay for renewing their lamps, this would probably add 40 per cent. to the total cost, according to the present price, or, taking gas and meters at 2s per 1,000ft., the electric light would in price be equal to gas at 3s. 5d. per 1,000ft. But the great advantages of electric lighting when compared with gas lighting as affecting health, goods, furniture, books, decorations, etc., and the absolute freedom of the electric light from explosions and personal injury, must be borne in mind.

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ELECTRIC LIGHTING AND TRANSMISSION OF POWER IN MINING.*

BY T. M. WINSTANLEY-WALLIS, A.I.E.E.

I.—ELECTRIC LIGHTING.

The application of electricity to mining (neglecting the familiar signals and exploders) may be divided into two heads—transmission of energy (*a*) for the purpose of lighting, and (*b*) for performing mechanical work.

The former is fairly well known, and is being employed more and more every year; amongst coal mines this rapid extension is mainly due to the fact (1) that the cost of electric lighting is practically the cost of steam power; (2) that the lights do not require individual attention; (3) that they do not flicker in the strongest wind; (4) that any candle-power from five to a thousand is easy of attainment on the same circuit; and (5) that no lighting, turning out, or trimming is required.

For underground lighting, the incandescent lamp is very valuable; in that strong currents of air do not affect it, that it will not fire gas when intact, and that it is nearly impossible for it to cause an explosion, even when broken accidentally.

In speaking of incandescent lighting, the writer should premise that he is referring to what is known as the low tension" or "low pressure," or "parallel" system. There are, broadly speaking, two ways in which electric lamps can be connected up: the "parallel" and the "series" systems. The system almost invariably used for incandescent lighting is the "*parallel.*" In this, two main wires run from the terminals of the dynamo, and the lamps are connected so as to form separate bridges between the mains; the dynamo maintains a constant electrical pressure between these mains; then, if the mains are bridged by a lamp offering a certain resistance to this pressure, a current (proportional directly to the pressure and inversely to the resistance of the lamp) will flow through it, and it will give a certain light; if another lamp is bridged across, of, say, half the resistance of the first one, obviously since the pressure is constant, double the current will flow, and double the amount of light be produced.

From this it will be seen that practically any number of different sizes of lamps can be used on the same circuit, and all lamps are independent of each other.

Lamps "in parallel" are extinguished or lit by interrupting or completing the circuit of the lamp between the mains. The "parallel" system is in no way dangerous to life, the pressure being only that required for one lamp, and the volume only of the current being increased as additional lamps are lit.

On the "series" system, the lamps are connected up one after the other in a continuous circuit. The positive terminal of the dynamo is connected to the first lamp, the first lamp is connected to the second lamp, and so on through the whole circuit to the negative terminal of the dynamo. Thus the same current passes through all the lamps in succession; the lamps are extinguished by giving the current an alternative path of lower resistance than the lamp, by connecting a wire to the main on each side of the lamp. This system is usually employed for long distance lighting with arc lamps, such as town lighting. With any considerable number of lamps in circuit it is dangerous to life; for since the same current passes through the entire circuit, the pressure increases in proportion to the number of lamps alight. There are several other methods of connection which, however, need not be discussed here.

The writer now proposes to enter into some calculation of the working cost, since that is the most important point in considering a system of lighting, and will take as an example a plant of the size recently installed at the Cossall Colliery, Ilkeston, under his supervision, of a capacity equivalent to 100 × 16 c.p. lamps. He will assume that, of the equivalent of 70 × 16 c.p. lamps on the surface, 26 will burn for 3,000 hours per annum, and the remainder (44) for 400 hours per annum.

Of the equivalent of 30 lamps underground, 20 will burn 3,000 hours per annum, and the rest (10 in number) for 7,000 hours; these latter are lamps which run continuously. (It may be stated here, that for easy calculation, the standard incandescent lamp at 16 c.p. is taken, and all lamps, though many will be of greater power, are reduced to the equivalent number of 16-c.p. lamps, which will take the same engine-power.) The total lamp-hours per annum of the above specified lamps will be about 222,000; to get the horse-power hours per annum, we may divide this by 10, since 10 × 16 c.p. lamps take 1 h.p. to drive them

	£	s.	d.
Assuming that a horse-power hour can be obtained for 10lb. of slack coal at 1s. 6d. per ton, the amount for coal will be, say, 110 tons	£8	5	0
Renewals of lamps on surface burning 3,000 hours twice per annum	8	10	0
Renewals of lamps on surface burning 400 hours ½ times per annum	2	5	0
Renewals of lamps underground burning 3,000 hours twice per annum	8	0	0
Renewals of lamps underground burning 7,000 hours 4½ times per annum	9	0	0
Interest and depreciation at 10 per cent. on capital outlay of £200	20	0	0
Oil, water, waste, etc.	5	0	0
	£61	0	0

This does not include the cost of an attendant for the dynamo, as, if not driven from the fan-shaft and looked after by the fan engine man, the small amount of attention required can be usually provided at a trifling cost.

	£	s.	d.
The gas used at 5 cubic feet per hour per 16 c.p. for 222,000 lamp-hours, multiplying by 5, will be 1,110,000 cubic feet, and this at 2s. 6d. per 1,000 cubic feet will cost	£138	15	0
Interest and depreciation of fittings and pipes, etc., say...	11	5	0
	£150	0	0

This is without any allowance for labour in lighting, etc., or leakage, which latter is a very serious item in a colliery, particularly when taken down the shaft. As yet arc lighting has hardly been mentioned.

Perhaps the greatest advantages of the "parallel" system are that every lamp is independent, and that, given a sufficiency of power and of dynamo capacity, any size of lamp can be run on the same circuit, and this applies to arc lamps as well as to incandescents.

On the "series" system it is obvious that, since large and small arcs require practically the same pressure, and since the same current traverses all the lamps, they must all be of the same size.

Arc lamps, however, though they cannot conveniently be smaller than 400 or 500 c.p., are much more economical than incandescents in the ratio of power consumed to light produced. For example, for 1 h.p. an arc lamp will give 1,000 c.p., a large incandescent 250 c.p., and small incandescents about 160 c.p. To set off against this, an arc lamp has the disadvantage that, while a 250-c.p. incandescent will last 1,000 or 1,500 hours, and need no attention, and then can be renewed for about 18s., a 1,000-c.p. arc in the same time will cost quite £3 in carbons and attendance. It should be stated that incandescents of various sizes can be run on a series circuit, as, though the current is constant, the pressure can be varied.

An accumulator or storage battery is a valuable adjunct to an installation, as it provides against possible stoppage through belts or ropes breaking, and, moreover, doubles the output of the plant if the dynamo is run to supply current at the same time as the accumulator is discharging; it is also a great convenience in private installations to charge during the day, and run off the accumulator at night.

The cost of an accumulator for the plant considered above, to run the whole of the lamps mentioned for 10 hours, will about double the cost of the plant, and increase the running cost by nearly 20 per cent.

In addition to the lighting functions of an electric light plant, the current can be utilised for signals, for firing fuses for blasting, etc., and power can be got by putting a motor on the circuit in exactly the same way as a lamp. This latter is a very valuable property, as a small fan or pump can be fixed for temporary work, and cables run to it in a few hours. The writer has heard people frequently say that "they should wait till more improvements were made before adopting electric light." It would, of course, be absurd to say that improvements will not be made continually in details, but this is going on in every other branch of engi-

* Paper read before the Chesterfield and Midland Counties Institution of Engineers.

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neering. The dynamo is the main thing, and a well-constructed dynamo of average size will give a useful return of 90 per cent. of the power put into it. This does not leave any great margin for improvement; and, if it *is* to be improved, it may be fairly said that perpetual motion is within the range of possibility.

It should be noted that collieries possessing an electric lighting plant are in a position to adopt electric safety lamps at a small outlay—referring, of course, to lamps using storage batteries, such as the Edison-Swan, Pitkin, and others, as it is not probable that lamps with primary batteries will be extensively used till zinc costs as little—weight for weight—as coal.

The following is a list of most of the collieries in Great Britain using electric light, for which the writer is indebted to the various Government inspectors of the districts:

List of Collieries Using Electric Light.

Derbyshire (6).		
Babington Company	Cinderhill	Colliery.
Cossall Company	Cossall	,,
Morris and Shaw, Limited	Birch Coppice	,,
Sheffield Company	Birley	,,
Stanton Company	Stanton Iron Works.	
Wass and Son	Mill Close Mine.	
Durham (3).		
Hetton Company	Elemore	Colliery.
Elliott and Hunter	Kimblesworth	,,
Earl of Durham	Herrington	,,
Manchester District (3).		
Fletcher, Burrows, and Co.	Atherton	Colliery.
Knowles and Sons, Limited		
Exors. of Colonel Hargreaves	Burnley	,,
Northumberland (3).		
H. Andrews, Esq.	Warkworth	Colliery.
Walker Company	Walker	,,
	Hilda	,,
North Wales District (1).		
	Foxdale Mine.	
South Wales (20).		
D. Davis and Sons	1, 2, 4, 5 Pits, Ferndale.	
Davis and Warner	Bodringallt	
Lockett's Merthyr Company	Mardy	Colliery.
National Company	National	,,
Watt, Ward, and Co.	Gnishir	,,
Glamorgan Company	Llwynypia	,,
Albion Company	Albion	,,
Plymouth Works	Abercarran	,,
Ocean Company	Park	,,
Nixon's Navigation Company	Merthyr Vale	,,
Ditto	Nixon's Navigation	,,
Ditto	Deep Duffryn.	
Harris' Navigation Co.	Harris' Navigation	Colliery.
Glasbrook Bros.	Gorsemon	,,
Thomas, Riches, and Co.	Clydach Vale	,,
Ebbw Vale Company	Ebbw Vale	,,
Powell Duffryn Company		,,
London and South Wales Company	Risca	,,
Ditto ditto	Abercarn	,,
Staffordshire (7).		
Cannock Chase Company	Cannock Chase	Colliery.
Cannock and Rugeley Company	Cannock and Rugeley	,,
Hamstead Company	Hamstead	,,
Madeley Company	Leycett	,,
Hawley and Bridgewood	Mossfields	,,
Norton Cannock Company	Norton Cannock	,,
Walsall Wood Company	Walsall Wood	,,
Wigan, etc (3).		
Nightingale, Potter, and Co.	Mesne Lee Colliery.	
Sparrow and Son	Ffrwd Iron Works	
Wigan Coal and Iron Company		
Total	42.	

II.—Transmission of Power.

Electrical transmission of power depends on what is known as the reversibility of the dynamo, which principle may be stated thus: a dynamo, if the armature is rotated by mechanical power, will generate an electric current, and if supplied with current will give out mechanical power just as an engine, if driven by another engine, will act as a pump, and if supplied with water under pressure, will give out power on its shaft.

This analogy also holds good, since a good engine by no means makes a good pump, nor does a good dynamo necessarily make a good motor.

When an electric motor is running, it has also a tendency due to its rotation to generate a current in an opposite direction to the current driving it; this produces a back pressure which checks the driving current; thus, when running free, this back pressure limits the current through the motor to the amount necessary to overcome its own friction; when a load is thrown on, the speed is slightly checked, and the back pressure thereby reduced, thus allowing a larger current, and one proportional to the load, to pass, and keep the motor up to its work.

From this it will be seen that an electric motor possesses great power of starting under a load, since when the motor is at rest the back pressure is zero, and a large current can pass; and since the torque, or turning effort of a motor, is proportional to the volume of current passing through it, an electric motor can exert at starting four or five times its normal power.

The losses of power in a system of power transmission are three: firstly, in the generator; secondly, in mains; and thirdly, in the receiver or motor.

In an electric transmission plant, the losses in the generator and motor together vary from about 40 per cent. in small machines, to as little as 10 per cent. in large ones. The loss on the mains depends on three quantities: the distance, the size of the main, and the volume of current; the loss may be regarded as being caused by something of the nature of frictional resistance of pipes, since it consists of a loss of electrical pressure in forcing the current through the wire. It is obvious that, other things being equal, the loss will vary directly as the distance.

With regard to the other two considerations, the resistance offered by a wire to the passage of the current is proportional inversely to the sectional area of the wire; thus, with a given current flowing along a given wire, and taking a certain amount of pressure to force it along, if the cross section of the wire is doubled, the amount of pressure required will be halved; also with a given wire, if the current is doubled, the amount of pressure required to force it through the wire is also doubled.

Now the energy of an electric current is made up of two factors—the pressure and the volume; taking a current of a certain pressure and volume, we shall get exactly the same amount of power if we double the volume and halve the pressure, and *vice versâ*. Thus it will be seen that since the loss on a given wire increases with the current, we must work with as high a pressure as is feasible; and also, since the loss decreases as the size of the wire increases, we must have as large a wire as possible. The limit in one direction is the pressure, which cannot be exceeded without danger to life, and in the other the size of wire, which will cost more in interest on capital cost than the annual cost of the horse-power expended in forcing the current through it.

At collieries, the cost of power is so small that it is generally advisable to have a rather large loss in the wire, and so use a small wire, and save in capital expenditure.

Electrical transmission of power is very flexible; it is possible to have motors of from one to 100 h.p. or over working on the same circuit. If a movable motor is required, it can be mounted on a truck, which can also carry a drum of cable to be paid out as the motor is moved.

The maintenance of a generator or motor must necessarily be less than that of any reciprocating engine, since the two bearings have no alternate push and pull to stand, but simply a continuous rotary motion.

Motors which require to be moved can be made to weigh as little as 70lb. per brake horse-power, and this with as high an efficiency as heavier stationary machines; and without any governing appliance, an electric motor will maintain a constant speed between no load and full load within 1 per cent. or 2 per cent.

Electric locomotives, either to carry their own power in the shape of secondary or storage batteries, as at the Wharncliff Silkstone Colliery in Yorkshire, or to take their current from a fixed conductor by a rubbing contact are coming into use, and an incidental advantage of electric transmission is that light can be obtained from the same circuit.

It may now be advantageous to compare shortly the most generally used systems of power transmission.

Transmission of power to a distance in mining is usually accomplished in one of five ways; by steam, wire rope, compressed air, water under pressure, and electricity. The

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writer does not propose to consider either steam or hydraulic transmission—as steam is wasteful, and only applicable for short distances on account of condensation; and hydraulic transmission is usually inconvenient on account of the effluent water, and inefficient where less power than the full capacity of the motor is required. He will, therefore, discuss only the comparative advantages and costs of wire rope, compressed air, and electrical transmission.

There are three points to be considered : capital cost, working cost, and convenience.

For short distances, quick-running wire rope is far the best on the first two heads. On the third head, it has always the disadvantages of requiring the guide pulleys to be oiled, and loss of power when deviating from a straight line, as well as great wear and tear. Slow-running rope is shown by the statistics of the cable tramways to only give a useful return of 25 per cent. to 30 per cent.

Air compressors and motors are always inefficient, and there is a large percentage of loss in the mains, while the first cost is rarely less, and under most circumstances greater than that of electrical plant; the mains are expensive to lay down, and not easily shifted when the position of the motor requires to be changed, and there are practically two sets of bearings, brasses, etc., to be kept in repair —the one counterbalancing advantage, as far as the writer is aware, being the ventilation secured by the exhauster in driving headings, etc.

The capital cost of electrical transmission plant is usually rather less than that of compressed air, and for long distances, also less than that of wire rope. For shorter distances, under about three-quarters of a mile, wire rope is cheaper in capital cost; and it is more economical in working up to about one mile, after which electricity has the advantage.

As far as convenience goes, electricity leaves little to be desired. The conductor, or main, is easily laid and requires no attention. When fixed, there is no loss of power in sharp bends, the efficiency is as great when lightly loaded as when working at full power. The motors are small for their power, and can be shifted from place to place, or worked on a truck with a drum of flexible cable, to admit of any desired movement for coalcutters, portable pumps, fans, etc.

The comparative merits of the various systems, however, depend on a combination of the capital and working costs, which is given in the form of a table, showing the cost of 1 h.p. transmitted to various distances.

The table is quoted from a paper by Mr. W. Geipel, of Edinburgh :

Total power trans-mitted.	System.	Distance in Yards.			
		110	1,100	11,000	22,000
H.P.					
5	Electric....	2·25	2·41	3·29	5·20
	Pneumatic	2·70	3·30	9 53	16·70
	Wire rope......... .	1·13	1·83	10·40	22·70
100	Electric.............	1 79	1·91	2·63	4·08
	Pneumatic	2·00	2·09	3·10	4·50
	Wire rope...........	1·07	1·22	8·83	9·73

From this it will be seen that electricity is far ahead of both the other systems considered at long distances, and for short distances, though surpassed by wire rope, it is well ahead of compressed air, and it is, besides, more convenient than either.

The writer will now give a few particulars of electrical transmission plants at present working.

At Trafalgar Collieries, Forest of Dean, a pump lifting 35 gallons per minute 90 feet, at a distance of half a mile, has been worked by a motor for five years, and a pump lifting 120 gallons per minute 300 feet high, at a distance of 2,200 yards, for over a year. The pump of the latter is a double-throw, with 9in. plunger and 10in. stroke, driven at 25 revolutions per minute by spur gear, reducing 6 to 1, and the small pinion is driven from the motor by a belt.

The current is carried by a $\frac{19}{18}$ copper cable on insulators, the return cable being an old 4in. wire rope. The efficiency from generator to motor is nearly 60 per cent., and the total cost per annum is £408; the water power, which was superseded, having cost £878. At these collieries a 6ft. fan is worked by a motor at a distance of one mile.

At St. John's Colliery, Normanton, a set of pumps lifting 120 gals. per minute 900 feet high, has been working since the beginning of 1888, with an efficiency between dynamo and motor of about 60 per cent. The output of the dynamo is 53 h.p., and the horse-power in the water 33. The loss in gearing, pumps, and water friction is 13 h.p., and the loss in the cables 2·5 h.p.

Finally, 50 h.p. is transmitted electrically to Solothurn, in Switzerland, from a water power at Kriegstetten, five miles distant, with an efficiency of nearly 75 per cent. These figures are sufficient to show that electrical transmission is not inefficient; its convenience is best proved by experience, which the writer hopes will not be wanting in the immediate future among colliery managers.

THE ELECTRIC LIGHTING OF BRISTOL.

MR. PREECE'S REPORT.

About a fortnight since Mr. Preece, the well-known electrical engineer of London, met the Bristol Sanitary Committee, and discussed with them the feasibility of lighting the city by electricity. After a long conversation, it was decided that Mr. Preece should prepare a report on the subject, and this has now been issued to the members of the Electrical Committee, accompanied by a letter intimating that the contents of report should not be disclosed until it had been dealt with by the committee. We learn, however, that Mr. Preece's report is of a very lengthy character, and very general in its terms. It refers to what has been done in other towns in the matter of electric lighting and the results that have been obtained. He admits that electricity cannot compete on very fair terms with gas. It cannot be supplied as cheaply as gas. His experience in the Post Office at London was that a gas-burner giving a 10-candle light cost about 18s. per annum, and an electric lamp giving the same amount of light, which, by the way, was maintained more uniformly and with comfort, cost 22s. per annum. That might be taken, Mr. Preece says, as the difference in cost. As a motive power, he points out that electricity could be obtained cheaper in Bristol than in London and other places on account of the price of coal in this centre. Mr. Preece's view is that the electric light is undoubtedly the light of the future. He did not anticipate it would in the least do any harm to gas, because there were various means to which gas could be applied. Mr. Preece supplies numerous statistics of the installations elsewhere, and says it would probably require a capital of £300,000 to undertake the business in Bristol. The Corporation would have to look the matter boldly in the face, but at the same time Mr. Preece states that the only Corporation which had undertaken the electric light was Bradford in Yorkshire, and as they had no experience of the management by a Corporation of the light, it behoved the Bristol Corporation to consider the matter very carefully. There were advantages in the Corporation undertaking the matter because they could get the money on advantageous terms; the light could be supplied at the lowest price to the consumer, and any profit arising could be applied to the reduction of the rates. Mr. Preece seems to favour the alternate current system which had been introduced in the lighting at Liverpool, Taunton, Exeter, and Bath.

STARTING OF THE BARKING-ROAD ELECTRIC CARS.—The first of the Electric Traction Company's cars, having been duly licensed by the police authorities and the Board of Trade, commenced running on the Barking-road section of the North Metropolitan Tramway Company on the 14th instant. A second car was put on the following day, and the six cars, which will shortly entirely supersede horses, will be placed in active work as soon as the drivers become accustomed to the new form of traction. These cars carry 52 passengers, and do 17 journeys daily, with one change of accumulators.

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THE

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BOUND VOLUMES.

Vols. I. and II., new series, of "The Electrical Engineer" *are now ready, and can be had bound in blue cloth, gilt lettered, price 8s. 6d. Subscribers can have their own copies bound for 2s. 6d., or covers for binding can be obtained, price 2s.*

IMPORTANT NOTICE.

The index of the current volume is given with this number, and every purchaser should receive it free of cost.

We commenced our report of the Paris Exhibition with a general article on the exhibits in our last issue, and the descriptions of special exhibits will appear from time to time till the whole have been described.

Specimen copies of the paper will be sent on request.

ELECTRICAL ENGINEERS AT PARIS.

The party of American engineers which have recently been welcomed by their English colleagues, and have now gone to the Great Exhibition to see how their French professional brethren order this kind of thing in their country, consists nominally of civil, mechanical, mining, and electrical engineers, but in reality the electrical portion of the profession is very inadequately represented. America can boast of a larger number of distinctly electrical engineers in proportion to general engineers than any other country, and as these did not come with the present expedition it is safe to assume that they will come later on, and probably they will choose the time of the Electrical Congress for their visit to Paris. Our American cousins are far too practical to care much for the academic, not to say abstruse, questions which the organisers of this congress seem bent upon discussing, but the congress will be an opportunity for meeting electricians of almost every country, and, therefore, it may safely be predicted that the largest number of English and American electrical engineers will visit Paris at that time. We believe this state of affairs has already been taken into account by the Council of the Institution of Electrical Engineers, and if rumour may be taken to be a true forecast of the Council's intention, it would appear that there will be a Paris meeting of the Institution held during the time of the congress. This meeting will of course be largely attended by American electricians, and that the leading French electricians will also take part in it goes without saying.

As regards numbers only, the members of the Institution are likely to be in the minority at their own meeting, but this should not be allowed to interfere with the character of that meeting. If the meeting is to be a success and creditable to the Institution, it should be of the same character as the meetings usually held at 25, Great George-street, that is to say, it should be essentially of a practical nature. No abstruse problems should form the subject matter for papers or be allowed to be introduced into the discussions on practical papers, and especially all questions of nomenclature should be strictly forbidden. Such questions are likely to be discussed *ad nausum* at the congress, and the electrical industries will be none the better for all the vast amount of learned talk which will be poured forth on this occasion by the professors of abstract science for their mutual glorification. The idea of the Institution holding a meeting in Paris this year is a good one, and should be heartily encouraged by all English electricians, but on one condition, and that is that the meeting should be perfectly independent of the congress, and should be essentially practical in its character. There can scarcely be a question that amongst

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European electrical societies, at any rate, the Institution takes the first rank. There is an International Society of Electricians in Paris, but it has only a kind of negative right to this title—namely, in so far as its proceedings are ignored by electricians of all nations outside the small group of French electricians who run it. In Belgium there is also an electrical society, but hardly to be compared with our Institution. The Berlin Society is somewhat better. It manages occasionally to secure a good paper, which is read outside its own circle of members, but the value of the papers is greatly diminished by the absence of anything like an adequate discussion. The society is completely under the control of a few large firms, whose representatives or servants are allowed to read papers, but are not allowed to discuss them, except in the most complimentary style, and anything like independent criticism is strictly tabooed. The proceedings of the Institution of Electrical Engineers are sometimes conducted in a warmer style than the sticklers for etiquette and decorum approve of, but they have, at least, the merit of being free and independent. Everybody is allowed to ventilate his views whether they be in accord, or in disaccord, with those of the "big firms," and in this freedom of discussion lies the principal value of the proceedings of the Institution. If a meeting is to be held in Paris let us have the same freedom of discussion, and let us have something worth discussing.

Now the question is, how can the latter condition best be attained? If the papers and the discussion thereon are to be supplied by the members of the Institution, there is no need to go to Paris to hold a meeting, since the same business could be transacted with very much more comfort and without expense in London. If the meeting is held in Paris it must be for some local reason. Now the only reasons which a scientific society has in organising a meeting are excursions to works and the securing of good papers, and in this connection we venture to make a suggestion to the Council of the Electrical Engineers which we hope they will take into serious consideration. They should make arrangements with French manufacturers of electrical apparatus for the inspection of their works, and they should endeavour to obtain, from French and other foreign authors, papers to be read at the meetings. There should be little difficulty in prevailing upon the various exhibitors of electrical apparatus to present to the Institution papers descriptive of them, and if the authors for commercial reasons should in some cases neglect to disclose all the scientifically important details, the process of free discussion which is a characteristic of the Institution, and to which we have already alluded, may be trusted to remedy the deficiency. The minutes of the Institution would thus become the most authentic and accurate record of the condition of the electrical industries in the year of the Great Exhibition, and acquire a practical value which can hardly be over estimated. We are quite aware that the programme we have here proposed for the Paris meeting of the Institution of Electrical Engineers will necessitate a considerable amount of work on the part of the Council and secretary of the Institution, and the success will also largely depend upon the exertions of the honorary secretary in Paris, but then the advantages which would result from this programme, not only to the Institution, but also to the electrical industries at large and to the French electricians in particular, are worth some little extra trouble. With Mr. Preece's and Mr. Aylmer's influence in Paris and with Mr. Webb's able and energetic co-operation at home, the success of the programme we have here briefly sketched may be confidently considered as assured.

THE MODEL ORDER.

The Board of Trade has issued a model provisional order, for a metropolitan order, in accord with the Electric Lighting Acts of 1882 and 1888 and the recent report of Major Marindin. As every firm and company desirous of obtaining such a provisional order must necessarily consult the idiosyncrasies of the Board of Trade, they will obtain this order therefore we may take it for granted that they either are, or soon will be, tolerably familiar with its clauses. We take it that this model is intended as a guide, and not to be too slavishly followed. Still there are clauses which must be common to all. The model must be more or less general, while each order granted will have to take into consideration the special character of the area over which the order extends. The Acts of Parliament and the regulations of the Board of Trade are intended, on the one hand, to facilitate the development of the industry by defining what may and what may not be done legally, and, on the other hand, to act as an arbitrator between the public and would-be "undertakers." Cannot some other word be found to express the people who desire to do the work, and this one be kept to its ordinary signification?

Besides this model order we have before us the orders granted to Messrs. Chamberlain and Hookham (Birmingham); the Liverpool Electric Supply Co. (Liverpool); and the Corporation of Swansea; from which it is evident that, as we say, the general portion of these orders is fashioned all on one principle, and many clauses are virtually the same. Each commences with a series of definitions which, though they may not be rigidly scientific, are practical, and continues with formal matters such as addresses and descriptions of undertakers, area of supply, etc., about which there can be few differences of opinion. Although a deposit has to be made to the

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Board of Trade the money is released as the work proceeds, so that no hardship arises from locked up capital. In the case of Birmingham the deposit is £2,000, released £500 at a time upon the certificate of the Board's inspector as to work done ; with Liverpool the amount is not so predetermined, and in the case of Swansea, being a Corporation order, the capital case is altogether different. It would be well for those interested to carefully study these three orders, as well as the model of the Board of Trade. A most important set of clauses relate to "nature and mode of supply," because the question of "earth" plays a prominent part in all electrical distributions. Practically at present all "undertakers" use a complete metallic circuit. No earth returns can be permitted from the evil effects which would arise to telegraphic, telephonic, and other light or power distributing systems. The time may come, and that right soon, when the telegraph and telephonic systems will have to contemplate "no earth possible." This is one of the largest questions affecting the newer industries, as the tendency is to use very high pressures, and a leakage to earth that may be unimportant to the "light" people may play havoc with telegraphy and telephony. We are quite sure, then, that these clauses must be regarded as temporary only. With the next section other important questions arise, and unless the action of some of these is carefully considered, the case will arise when the "undertaker" under the order is in a worse position than the free lance who troubles about nothing but way-leaves. Neither existing Acts of Parliament, nor Board of Trade, nor County Council can say to the private contractor who has secured way-leaves, "Thus far shall thou go and no farther." These authorities can no more stop overhead wires erected as we have described than they can stop overhead telephone or telegraph wires, and this is as it should be, for, in our opinion, neither telephony, nor telegraphy (outside the Post Office system) should be allowed to claim vested rights in overhead wires or stop other industries from using similar wires. We are opposed, in such places as London, to all overhead wires, but if they are to be allowed at all, no restriction must be placed upon the industries that may utilise them. Returning to the "works" clauses, they may be taken to be an attempt to mediate between all the authorities interested, and, like all such attempts, will receive criticism all round, yet the unbiassed observer will be forced to admit the difficulties of the position, and acknowledge that every attempt to please all parties will probably end in pleasing none. The pith of the nine pages of clauses is that other people's interests must not be interfered with, and due notice must be given of interference with existing works, pipes, tram lines, bridges, streets, etc., etc., and when touched these must be put right again at the undertaker's expense. The following clauses relating to compulsory works must speak for themselves; we are unable to translate them into plain English:

"19. The undertakers shall, within a period of two years after the commencement of this order, lay down suitable and sufficient distributing mains for the purposes of general supply throughout every street or part of a street specified in that behalf in the second schedule, and shall thereafter maintain the same.

"20. In addition to the mains specified in the last preceding section the undertakers shall, at any time after the expiration of eighteen months after the commencement of this order, lay down suitable and sufficient distributing mains for the purposes of general supply throughout every other street or part of a street within the area of supply, upon being required to do so in manner by this order provided.

"All such mains as last above mentioned shall be laid down by the undertakers within six months after any requisition in that behalf served upon them in accordance with the provisions of this order has become binding upon them, or such further time as may in any case be approved of by the Board of Trade."

The section on testing seems very cumbersome, and we doubt if it is workable, but this question will have to be discussed at a future time at considerable length, and for the present we must leave these orders.

THE ROYAL AGRICULTURAL SHOW.

Year by year, as the Royal Show comes round, the exhibits of electrical apparatus, or of machinery concerned in the production of electricity, become more numerous. This year the site of the Show, which is one of the largest the Royal Agricultural Society have ever held, is Windsor Home Park. Prettier or more interesting surroundings there could hardly be, and owing to its accessibility from the metropolis, the attendance has been very large.

There is a splendid collection of engines on the ground, both steam, gas, and oil; and most of the big builders are represented. Taking them in alphabetical order, and dealing first with steam-engines, Messrs. Charles Burrell and Sons, of Thetford, Norfolk, exhibit a 16 h.p. compound undertype engine, fitted with automatic expansion gear controlled by the governor, and specially adapted for driving electric light machinery. Messrs. Clayton and Shuttleworth, of Lincoln, show an 8 h.p. portable, and a compound engine of 12 h.p. of the undertype class. Messrs. Davey, Paxman and Co., of Colchester, are well represented by engines of their well-known types, which we have so frequently described in these columns, and by their vertical Essex boilers, to which we referred in our de-cription of the Nottingham Show last year. Messrs. John Fowler and Co., of Leeds, have two engines, which we may specially notice, and hope in due course to illustrate and describe in detail—viz.: Scott's patent high-speed for dynamo driving, and a horizontal compound engine of 25 h.p., named the "Juanita," made for Colonel North, to be used in the installation at his house. It is fitted with automatic expansion gear on both cylinders, which is controlled by one governor, and has sight-feed and drop-sight lubricators and indicator gear. Mr. E. S. Hindley, of Bourton, D rset, always has a capital show of his small-power engines, and the present year is no exception to this rule. Messrs. R. Hornsby

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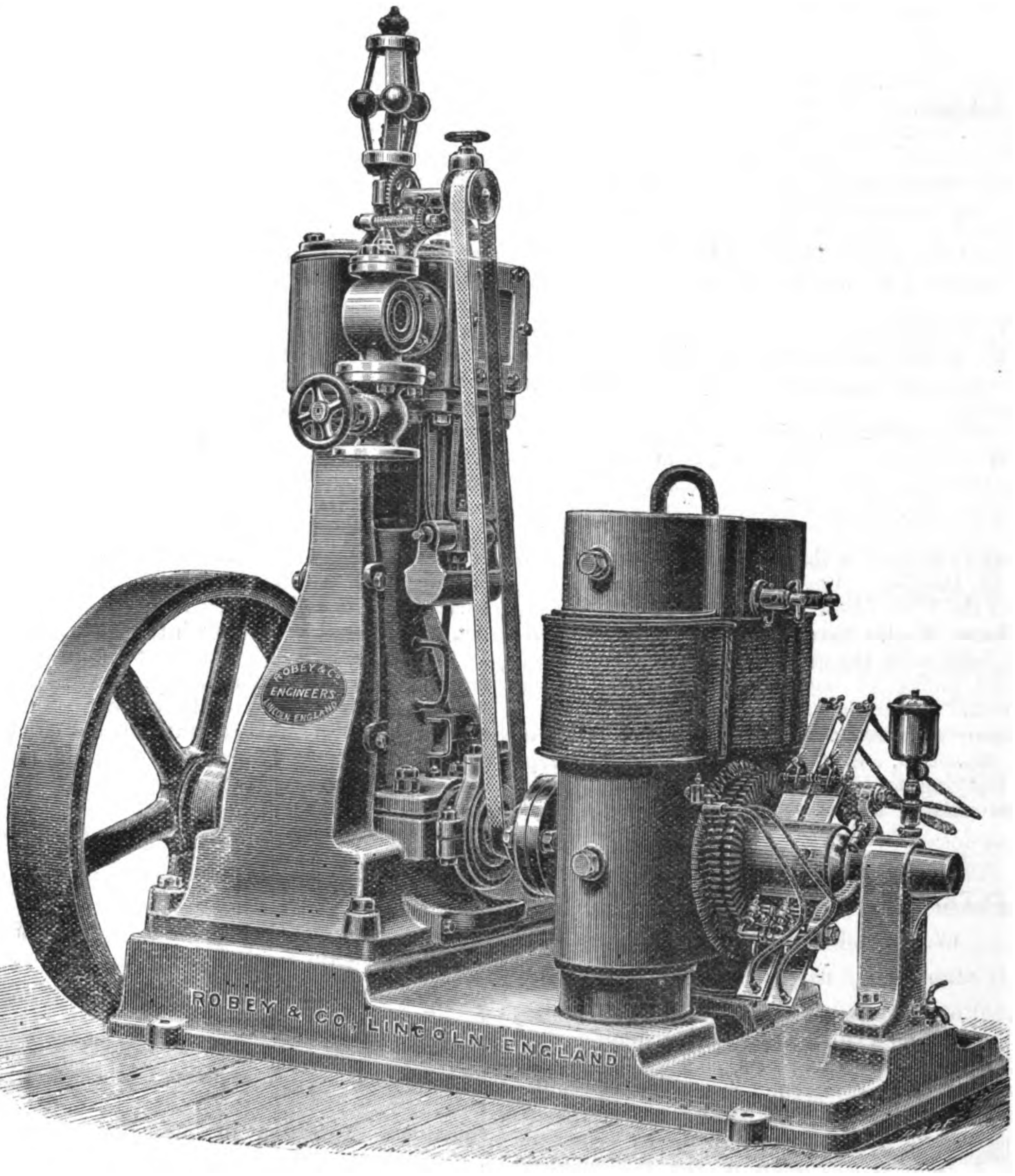
AND SONS, of Grantham, besides their ordinary types, which are so well known to our readers, exhibit a new rotary engine, of which they hope great things. MESSRS. J. AND H. GWYNNE, of Hammersmith; MARSHALL, SONS, AND CO., of Gainsborough; RANSOMES, SIMS, AND JEFFERIES, of Ipswich; and RUSTON, PROCTOR, AND CO., of Lincoln, are firms who may be depended upon to supply good engines for any purpose.

Special attention has been given by many firms to the supply of engines to occupy a small space, run for long periods under considerable difficulties without giving trouble, wear well, cost little for maintenance, and be fairly economical steam users, in order to drive dynamos direct for ships' lighting. Among this class of engine, that shown by Messrs. ROBEY at the Royal Show (illustrated herewith) must take a very high place. The engine is intended to run at from 300 to 400 revolutions, and that exhibited is coupled to a Holmes's dynamo. The engine is thoroughly well built, and is spoken of with great praise by those who have used it. Every attention has been paid to lubrication, and the whole design and manufacture seems to have received the most careful consideration.



Robey Engine and Holmes' Dynamo.

Gas and oil engines are shown by MESSRS. J. E. H. ANDREW AND CO. of Reddish, Lancs., and London; THE BRITISH COMPANY, of Albion Works, Gospel Oak, N.W. (Atkinson's patent cycle); CROSSLEY BROS., Openshaw, Manchester (the "Otto"); DICK, KERR, AND CO., Kilmarnock, N.B., and London; J. H. KNIGHT, Barfield, Farnham, Surrey (a new paraffin oil engine); PRIESTMAN BROS., Hull (Priestman, Hume, and Eteve's petroleum engine, of which we illustrate a new portable form just brought out by the firm). This is a 6 h.p. (nominal) engine, and the makers claim that it is the first to be introduced as such to the public. In this form it is claimed that it is useful for many purposes, and in all cases where the portable steam-engine has hitherto been used, and as it requires no driver, and but little attention, it is likely to answer its purpose well. A 4 h.p. nominal horizontal type is exhibited, driving a 50-light dynamo, showing the utility of the engine for this purpose; the general design has been much improved upon, both as to compactness and otherwise, and the engine is now so constructed that every part is easily accessible. The third engine exhibited is a 1 h.p. horizontal type, similar in construction to the foregoing, but has an air compresser mounted upon sole plate at end of engine, and connected directly with same by gearing. This shows another application of the engine, which arrangement can be utilised for other purposes, such as pumping, etc. An improved method of supplying electricity for ignition purposes by means of a small storage cell, is also shown with the engines exhibited. The advantages of this improvement can be readily realised when it is considered the cell will last for about three months without being recharged. In connection with the dynamo before mentioned are exhibited some electrical plant provided by Messrs. Lea, Sons, and Co., of Shrewsbury.

Of turbines and water-wheels there are numerous exhibitors. MESSRS. GILBERT GILKES AND COMPANY, of Kendal, show a number of their useful vortex turbines, also a water-pressure reducer (Braithwaite's patent). MESSRS. J. J. ARMFIELD AND COMPANY, of Ringwood,

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Hants, have brought out a new form of turbine, which they term the "British Empire." In this the water is admitted by means of double gates, working horizontally instead of vertically, which, so the makers claim, renders their working easier under a head of water. The turbine and water inlet is self-contained and ready for building into brickwork.

MR. C. L. HETT, of Brigg, Lincolnshire, has one of the best and most varied collections of turbines that has been seen at the Royal. One of these, "The Hercules," is only the second of this variety ever seen in England. It is destined for use in an electric light installation. Mr. Hett has had a large experience in turbine building, and if he cannot turn out a good one no one else can.

MESSRS. ABBOTT AND CO., of Newark-on-Trent, exhibit some of their "handy" hoists, which have come into use for elevating arc lamps. They are provided with two speeds capable of lifting 10cwt. and 20cwt. respectively. They are compact and neat.

MESSRS. T. J. SYER AND CO., of 45, Wilson-street, Finsbury, E.C., exhibit a new carpenter's bench with several improvements, among which may be mentioned instantaneous grip vices, screw stops, and a well down the centre, in which tools can be laid without interfering with the flat surface of the table. Messrs. Syer supplied six of these benches to the City and Guilds for their students' workshop.

MESSRS. W. F. DENNIS AND CO., of 11, Billiter-street, E.C., agents for Felten and Guilleaume, of Cologne, show their specialities on this occasion, chiefly, of course, of an agricultural kind.

In addition to a number of engineers' tools and sundries, MESSRS. W. H. WILLCOX AND CO., of 36, Southwark-street, S.E., exhibit specimens of their engine-packings and well-known lubricating oils, which have come largely into use for dynamos.

Pulleys were to be seen at the stands of MESSRS. J. and J. MACKIE, of Reading. MESSRS. F. MORTON AND CO., Liverpool, and the UNIVERSAL PATENT PULLEY COMPANY, Reading. Messrs. Mackie have introduced an interchangeable bush for pulleys, by the use of which no key is needed. Both bush and pulley are bored oval, and a dead grip is got by differential movement of the pulley on the wheel.

MESSRS. IMMISCH'S electric waggonette was a centre of considerable attraction, and their representative was kept very busy replying to the hundred and one questions of those who wanted to know "how the wheels went round."

ELECTRIC MOTOR REGULATION.*

BY FRANCIS B. CROCKER.

(Concluded from page 503.)

Case 2 is that of the ordinary shunt or differential motor, with a variable load on a constant-potential circuit. This is self-regulating and maintains its constant speed, as already stated, and is the commonest case of motor regulation met with. The current varies directly with the load.

Case 3 is that of the ordinary shunt motor with constant load, having a variable resistance in the field-magnet. This case is shown in Fig. 1. Increasing resistance of field circuit would weaken the field magnetism and the motor would run faster and take more current—*i.e.*, current would vary directly with speed.

Case 4 is not a practical one, because, if potential, speed and load are constant, the current cannot be varied without wasting it; that is, any excess of current would be simply destroyed, which, of course, is not permissible.

Case 5 is not likely to occur, because potential and current would not be constant with a variable load and speed, but if it did occur it would require that the speed and load should vary inversely.

Cases 6 and 7 are not practical for the same reason as given in case 4, because if potential, current and speed were constant the load could not be reduced without wasting electrical energy, and in case 7 the speed could not be varied without wasting energy.

* Paper read before the American Institute of Electrical Engineers. For the illustrations referred to see our last issue.

Case 8 is that in which all four factors are constant, and is best illustrated by a shunt motor with constant load on a constant-potential circuit, in which case the current and speed would also be constant.

Case 9 may be illustrated by a shunt motor with variable load on a constant-current circuit. The speed would run up as the load reduced. A more common example is a series motor on constant-current circuit, with switch for cutting out field-coils, or, in short, a constant-current motor with variable speed and load.

Case 10 is that of the regular constant-current or "arc" motor with governor, such, for example, as the Baxter or "C. and C." It is a series motor with a centrifugal governor which operates a switch to cut in and out the field-coils, as shown in Fig. 3. This is, next to the shunt and differential wound motors, the most common and important case of motor regulator.

Case 11 is that of a constant-current motor with constant load, with switch for vary field strength. The potential would rise directly with speed, but this case is not likely to occur.

Case 12 is not practical for the same reason as given in case 4.

The last four cases are those in which both potential and current vary. They are hardly practical cases, because electrical distribution is almost always either at constant current or constant potential. It is, however, of course, possible to have cases where both may vary, and examples of each case are given.

Case 13 is one which does occur to a certain extent in practice; for example, if a so-called constant-current circuit varies slightly, as it always does in practice—say, from nine to 10 amperes, then the current as well as potential is variable to that extent, and this must be taken account of in the regulation.

In the experiments which I have already referred to, Mr. Wheeler and I have built a motor of the constant current type which will govern for wide variations in current as well as in load. This motor, for example, will not fall in speed, even though the current be reduced from 10 to 5 amperes, which is a great variation for this type of motor, as the field and armature, being in series, the torque varies as the square of the current. This variation in current in the so-called constant-current circuits is a much greater percentage than the variation in potential of so-called constant-potential circuits, and amounts to $\frac{1}{2}$ to 1 ampere.

Having generally described the different cases of motor regulation, let us take up the mathematical relations of potential, current, speed, and load, which may be expressed quite simply.

Using the symbols P C S and L, as defined above, we have $P \times C$ as the total electrical energy supplied to motor in watts, or $\frac{P\,C}{746}$ in horse-power. Calling commercial efficiency a, the actual mechanical horse-power developed by a motor is $\frac{a\,P\,C}{746}$, expressed in electrical terms. The equivalent expression in mechanical terms is $\frac{2\,\pi\,S\,L}{33{,}000}$. Since the point at which load, L, is measured is 1ft. from centre of shaft, and travels $2\,\pi$ feet per revolution, or $2\,\pi\,S$ feet per minute. This, multiplied by the load and divided by 33,000, gives the horse-power developed by the motor.

Thus, we have $$\frac{a\,P\,C}{746} = \frac{2\,\pi\,S\,L}{33{,}000} = \text{h.p. of motor},$$

or $$P\,C = \frac{746 \times 2\,\pi\,S\,L}{33{,}000 \times a} = \frac{S\,L}{7 \cdot 04 \times a}.$$

For convenience, we may write $P\,C = \frac{S\,L}{7a}$ with an error of about one-half of 1 per cent.

If the efficiency, a, of motor is 85·2 per cent. the denominator, or $\cdot 04a$, becomes 6 exactly, and we have $P\,C = \frac{S\,L}{6}$; and if the efficiency is 75·8 per cent., we have $P\,C = \frac{S\,L}{5}$. The former is as high and the latter is as

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low as is ordinarily met with in practical work; therefore, these are the limiting values.

The equation $P\ C = \frac{S\ L}{7{\cdot}04\,a}$, or one of the three simplified forms just given, may be advantageously used for solving problems in motor regulation. If we know any four of the quantities we may, of course, find the fifth by simply solving the equation with respect to it. It is also evident that if any three of the quantities are constant then the other two will vary directly or inversely with each other, depending upon their position in the equation. This is the ordinary case we have to deal with in regulation. Usually speed is required to be constant, either potential or current is maintained constant, and efficiency should be practically constant down to very small loads; thus we have either current or potential or load varying directly with load. The efficiency is rather a confusing element in motor regulation. For this reason it was not introduced as a fifth quantity in the second table, as it would have complicated it, and made a great many more possible cases. The efficiency should be high (close to 100 per cent.), and as nearly as possible constant, therefore it would not affect the figures much.

If the load or speed is zero, or very low, the potential or current should be correspondingly reduced, and the efficiency would remain constant. This is the condition for perfect regulation. Practically, it always takes some current to overcome friction, etc., even when load is zero, in which case efficiency is zero, but this current should be very small.

The equation $P\ C = \frac{S\ L}{7{\cdot}04\ a}$ applied to the cases marked "not practical" in second table, shows in case 4, for example, that if P, C, and L are constant, the efficiency, *a*, decreases directly with reduction in speed. This is not allowable. The same is true of the other cases, and shows that it is not proper to vary P C L simply at the expense of efficiency, or, in other words, waste current, to obtain regulation.

Having now given the general points of motor regulation, we will consider the forms of motors which are now being used extensively.

First and most important, we have the regular shunt motor for constant-potential circuit, which has already been referred to several times. Thousands of this type of motor are in use, and give very satisfactory results. A properly-designed motor of this kind will regulate within 5 per cent., which is near enough for most purposes. It has no regulating mechanism or complicated circuits to get out of order, and it may be called the ideal self-regulating machine. The next important form is the differential wound motor, which is even more perfect in closeness of regulation, theoretically, and it might be made almost absolutely constant in speed; practically, the speed varies about 2 per cent.

These are the figures given me by the company who manufacture these machines in the largest quantity and of the most excellent workmanship. Silvanus Thompson gives an example of one of these machines, which only varied ½ per cent. in speed, with a variation from 1·1 to 11·14 h.p.

The rule for winding differential motors is that the number of turns in the shunt divided by the number of turns in the series-coil are equal to the resistance of the shunt divided by the resistance of the armature plus the resistance of the series-coil. On this side of the Atlantic this is called Sprague's law of winding; on the other side it is called Ayrton and Perry's rule for winding. The slight variation in speed which does occur is due to the heating of the two coils and other slight disturbances. The shunt-coil varies considerably in resistance effected by heating; therefore the series-coil should have a few less turns than the rule requires. The heating of the shunt-coil weakens the current in it, and consequently the field magnetism, thus increasing the speed of the machine; therefore the motor runs faster after it has been running for some time. The proper way is, of course, to consider the true speed to be that which the motor has in steady running. At first, some trouble was experienced in this type of machine on account of short-circuiting between the series and shunt-coils, but this has been overcome by more perfect insulation.

The shunt or differentially-wound machines may be varied in speed by putting resistance in the field circuits, as shown in Fig. 1. This may, of course, be done automatically, or by hand, usually the latter.

The next important type of machine is the constant-current motor. As already stated, this is merely a series-wound machine, with switch for cutting in and out the field-coils, the latter being operated by an automatic centrifugal governor, as indicated in Fig. 3, or by hand. Various modifications of this type have been made—for example, a reversed coil may be wound on the field-magnet-coil and having a variable resistance in circuit with it. If this resistance is very high, the reversed coil has little or no effect. If this resistance is made very low, it will rob the main coil of its current, and also neutralise its effect, thereby greatly reducing the strength of the field-magnet. All these motors with varying field strength have the drawback that a certain time is required for the magnetism to vary, and the regulation is therefore sluggish. If we attempt to hasten this by laminating the field-core we have sparking at switch points, due to self-induction in field-coils.

Constant-current machines with regulator are now in great demand for arc circuits; in fact, it is not practical or safe to use a motor on an arc circuit without a regulator, as the danger of racing away is very great.

The differential winding of constant-current motors to maintain constant speed is not practicable. The solution of it requires either that the efficiency should be very low, or that storage batteries be used in connection with the motor to maintain a constant difference of potential. Any such plan as this is, of course, very objectionable.

The three types just given are really about the only continuous-current motors, used to any extent, in practice, and it seems that there is at present no demand for any other type.

Nothing has been said of the regulation of alternating-current motors, because it is a radically different subject, and, moreover, alternating-current motors tend to run synchronously, maintaining a constant speed and regulating themselves.

In conclusion, I would say that I would like to see this subject taken up by leaders in electrical science and given the attention which I think it deserves.

BIRMINGHAM ELECTRIC LIGHTING ORDER.

The Bill for confirming the Board of Trade provisional orders for electric lighting at Birmingham, Liverpool, and Swansea was issued on Tuesday as a Parliamentary paper. The Birmingham order, as agreed upon between the Board of Trade, the promoters, and the City Council, is granted to Arthur Chamberlain and George Hookham, of New Bartholomew-street, Birmingham, electrical engineers, but it is provided that none of the powers conferred by the order in relation to works or otherwise shall be exercised unless and until the undertaking has been transferred to a company duly constituted under the Companies Acts 1862 to 1882, or by a special Act of Parliament, and having a capital of not less than £50,000, and upon the transfer of the undertaking to such company that company shall be the undertakers for the purpose of the order. The area within which the undertakers are authorised to supply energy is described in Schedule A as follows: "So much of the borough of Birmingham as lies between the line formed by the following streets or parts of streets—namely, from the junction of Edmund-street and Easy-row, along Edmund-street to its junction with Livery-street, and thence along Livery-street to its junction with Colmore row, and thence along Colmore-row to its junction with Bull-street, and thence along Bull-street to its junction with the Minories, and thence along the Minories to its junction with the Old-square, and thence round the Old-square to the corner of the Upper-priory, and thence continuing round the Old-square down Corporation-street to its junction with Lawrence-street, and thence back along Corporation-street to its junction with Bull-street, and thence along Bull-street to its junction with Albert-street, and thence along Albert-street to its junction with Fazeley-

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street, and thence along Fazeley-street to its junction with New Canal-street, and thence along New Canal-street to its junction with Bordesley-street, and thence along Bordesley-street to its junction with Park-street, thence along Park-street to its junction with Paternoster-row, thence along Paternoster-row to its junction with Moor-street, thence along Moor-street to its junction with Carr's-lane, thence along Carr's lane to its junction with High-street, thence along High-street and down the Bull-ring to its junction with Moor-street, thence across the Bull-ring and along Bell-street to its junction with Worcester-street, thence along Worcester-street to its junction with New-street, thence along New-street to its junction with Paradise-street, thence along Paradise-street to its junction with Easy-row, and thence along Easy-row to its junction with Edmund-street." The capital of the undertakers (being such company as above mentioned) for the purposes of the order is to be not less than £50,000, and the undertakers within a year from the commencement of the order, and before exercising any of the powers conferred upon them in relation to the execution of works, shall by special resolution cause such capital to be appropriated as a separate capital for the purposes of the undertaking; and if the undertakers fail to cause the capital to be subscribed and appropriated, the Board of Trade may revoke the order upon such terms as they think fit. The undertakers are also required within a year, or such extended period as the Board of Trade may approve, to deposit £2,000. The deposit will be repaid from time to time in sums of not less than £500, when and so soon as an inspector of the Board of Trade certifies that sums of that amount have been expended upon works for the purpose of the undertaking. The order contains clauses relating to the nature and mode of supply, and providing for the protection of various public interests. It is provided that the undertakers are within three years of the commencement of the order to lay down suitable and sufficient distributing mains for the purpose of general supply throughout every street within the specified area.

LEGAL INTELLIGENCE.

KING, BROWN, AND CO. v. THE ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION, LIMITED.

This is an action in the Court of Session, Edinburgh, before Lord Trayner, at the instance of King, Brown, and Co., Rosebank Electric Works, Broughton-road, Edinburgh, against the Anglo-American Brush Electric Light Corporation, Limited, 6, York-place, Edinburgh, for the reduction of letters patent obtained by the defenders in October, 1878, and other papers, for "improvements in apparatus for the generation and application of electricity for lighting, plating, and other purposes." The pursuers alleged that the defenders had threatened them with legal proceedings and liability in respect of the manufacture, use, or sale of the alleged invention said to be covered by the letters patent, and in particular of compound-wound dynamo machines. These threats, the pursuers said, had very seriously affected their business; and as, they alleged, the defenders' patent was anticipated by Varley, they were entitled to manufacture dynamos wound in series-shunt. In point of fact, they held that Varley had first discovered series-shunt winding, and that the defenders' alleged patent was therefore invalid. This was totally denied by the defenders, who maintained that they first discovered the series-shunt system, and that they were the first to apply it to its present purposes. A long proof was had some time ago, and on Wednesday Lord Trayner gave judgment.

He said: The question to be determined in this case is whether Mr. Brush is the inventor of (1) the peculiar form of commutator; and (2) the series-shunt machine for which the letters patent now under reduction were granted. In regard to both, the pursuers maintain that Mr. Brush is not the first and true inventor, and that both had been publicly known and used prior to the date of the letters patent. To some extent the determination of the question at issue depends upon the construction of Mr. Brush's patent obtained in 1878, and the patent obtained by Mr. Varley in 1876; to some extent also on matters of fact which are disputed. A long proof has been led before me from which it was not possible at the time to exclude evidence which ultimately resolved itself into expressions of opinion as to the meaning and construction of the two patents. In forming my judgment upon the questions submitted to me, I have carefully considered the proof, in so far as it was necessary thereby to instruct myself on scientific theory and detail, and in that respect I have obtained great assistance from the evidence adduced on both sides. I would like to add that I have been greatly assisted also by a remarkably able argument from both sides of the Bar. But in construing the letters patent I have put aside the different views of the witnesses on both sides, as construction is a matter for the Court, and not for the witnesses. In disposing of the case I shall deal separately with the questions connected with the commutators and the series-shunt machine.

First, as regards the commutator, Mr. Brush describes his invention in the provisional specification in these terms: "In constructing commutators cylindrical with an insulating hub or body to which are attached metallic sub-segments placed in electrical connection with the general mechanism in which the commutator is employed, and metallic wearing sub-segments detachably attached to said sub-segments." This is said to have been anticipated by Varley's commutator and the Manchester commutator, both of which have been produced. With regard to both of the last-mentioned commutators, I think it may be said that they are cylindrical, with metallic sub-segments having metallic wearing segments detachably attached. They also had an "insulating body"—or, I should rather say, "insulating substance," for the word "body" is ambiguous. Yet, with all those points of similarity, I do not regard them as anticipations of the defenders' commutator. The insulating hub or body of the defender's commutator is the "body" or basis on which his commutator is constructed, to which the various parts of his commutator are attached. This cannot be said of the Varley or Manchester commutator, in which the insulating substance does not form the body or basis of the commutator at all, and insulates not the whole commutator, but only one section of it. The purpose and effect of the Varley and Manchester commutators, electrically considered, were in my view the same as Brush's commutator; but it is not in that view that Brush claims that his commutator is a new invention. He claims it merely as a mechanical device or arrangement having certain advantages over existing arrangements used to serve the same purpose. But as a mechanical arrangement, I think it was new and useful, and not open to challenge. But the pursuers maintain that the letters patent under reduction are rendered invalid by reason of the patentee claiming in his final specification (as amended and disclaimed) something with reference to this commutator as an invention which is not foreshadowed in the provisional specification. The claim here referred to is the fourth, which is in these terms: "The commutator having metallic insulating segments T substantially as shown in division three." It appears to be necessary, or at least desirable and advantageous, to cut the armature bobbins out of circuit when they are crossing the neutral or current-reversing points of the magnetic field. To do this the continuity of the current-conducting segments of the commutators has to be broken, either by a mere space or by the insertion of some non-conducting material, at the given point. The cutting of the bobbins out of circuits was known and practised before the date of the defenders' patent; but it was not before then done by means of an insulated metal segment. The advantage which attaches to the defenders' method is this, that the insulated segment being metal like the conducting segments there is ensured a certain uniformity of wear over the entire surface of the commutator, which could not be preserved where a softer material like wood was used, or where merely a space was left. I am not aware that prior to the defenders' patent, any insulating body, metal or otherwise, was ever used, in the construction of the commutator, for the purpose of cutting the bobbins out of circuit. The insulating segment T of the defenders' patent was therefore a novelty, and its utility I do not understand to be disputed. But was it foreshadowed by the provisional specification? I think not.

In the first place, the defenders' second claim seems to me to be co-extensive with the provisional specification (in so far as it relates to the commutator) so that there was nothing left to claim under another head. If all that was foreshadowed in the provisional specification is included in the second claim, then the fourth claim (unless regarded as mere repetition, which nobody suggests) is for something not there foreshadowed. Secondly: the provisional specification relates only to the construction of a cylindrical commutator, whereas one of the chief purposes of, and one of the main advantages to be derived from, the insulating segment T is the preservation or maintenance of the cylindricity of the commutator: an object probably as important and as patentable as, but quite distinct from, the shape or mode of construction. Thirdly: the insulating segment T is not merely or necessarily a part of the cylindrical commutator having sub-segments with wearing segments detachably attached. It has and is intended to have a peculiar function which is not referred to in the provisional specification at all. Fourthly, it is said that the segment T is a part of the wearing segment, and therefore falls within the description of the provisional specification; but I think this is not so. The wearing segment is an essential part of the defenders' commutator. The segment T is not; it may be dispensed with altogether. I come, therefore, on this part of the case to the conclusion that the patent sought to be reduced is invalid in respect the invention claimed in the final specification is larger and different from that claimed in the provisional specification.

It is right, notwithstanding what I have said, that I should also express my opinion upon the remaining question in the case—viz., was Mr. Brush the inventor of the series-shunt machine, or had that invention been anticipated by Varley? For the pursuers it is maintained that Varley disclosed and published the invention of a series-shunt machine in his specification and patent of 1876, and constructed a machine in conformity with that specification, which was a series-shunt machine, and was publicly used as such in 1877. The defenders' patent, as I have said, is dated in 1878.

In considering whether the description given by Varley in his specification amounts to a publication of the invention claimed by the defenders, it is necessary to bear in mind the two different kinds of winding used in dynamos known at the time when Varley's specification was lodged. The first of these was the series. In the series machine, one wire was coiled round the magnets, and the current sent along this wire served both for the excitation of the magnets and the performance of the external work. There was thus one wire and one circuit. In the second—the shunt machine—there was again only one wire coiled round the magnets, but the electricity developed by the machine instead of being entirely conducted in one circuit (as in the series machine) was bifurcated immediately as it left the machine.

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and one part went wholly to the excitation of the magnets, while the other went wholly to the performance of the external work. The current was thus divided in two, each part of which formed a branch or circuit quite independent of the other. The defects or weak points in each of these machines has been clearly explained by Mr. Imray, and need not here be repeated. These defects found their remedy in the third kind of machine now known as series shunt, which, speaking generally, is a compound of the other two ; it is in effect a series machine, with a shunt added to it. In this machine, the magnets are wound round with two insulated wires, one having a higher resistance (the shunt-coil) than the other (the series-coil). The electricity produced by the machine is diverted or bifurcated immediately after it leaves the armature ; part of it is taken by the shunt to magnetise the magnets, the remainder of it being conducted by the other wire (the series), so as to (1) excite the magnets and (2) perform the external work. The shunt-circuit is always closed, the other may be either closed or open. Thus, whether the series-circuit is closed and is exciting the magnets and doing external work, or is open and conveying no energy, the shunt-circuit is engaged in keeping the magnets sufficiently magnetised. For if the series-circuit is open, the only path from the armature being by the shunt more of the energy produced in the armature will pass through the shunt-circuit, and the effect of the shunt in exciting the magnets will be increased, thus compensating for the absence of any excitation from the series-circuit. The magnetisation of the magnets is in this manner maintained, so that the machine is kept ready to do full work on the series-circuit being again closed.

I turn now to Varley's description, which, for convenience, I here quote. He says, describing his machine : "Part of the electricity developed by the machine is diverted to maintain the magnetism of the soft iron magnets, and the remaining portion is used to produce the electric light. There are several well-known ways of doing this, but the method I prefer is to wrap the soft iron magnets with two insulated wires, one having a larger resistance than the other. The circuit of large resistance is always closed, and the circuit of less resistance is used for the electric light. When the electric light is being produced, the greater portion of electricity passes through the circuit of less resistance, which I term the 'electric light circuit,' maintaining the magnetism of the magnets and producing the light. When the electric light circuit is opened from any cause, the electricity developed passes through the circuit of greater resistance only, and maintains the magnetism of the magnets." In this description I find disclosed (1) that the electricity developed by the machine is diverted or divided, one part going to maintain the magnetism of the magnets, and the remainder going to produce the electric light ; (2) that the method by which this may be accomplished (and the method which Varley prefers) is by wrapping the magnets with two insulated wires, one having a larger resistance than the other ; (3) that the circuit of larger resistance is always closed, and the current passing through it maintains the magnetism of the magnets ; and (4) that the current passing through the circuit of lesser resistance is used for "maintaining the magnetism of the magnets and producing the light." These four things appear to me to comprise every distinctive feature of a series-shunt machine. The series arrangement and the shunt arrangement are combined with the compensating or self-regulating result to which I have already alluded.

The defenders' scientific witnesses all express in their examination in chief the opinion that Varley did not disclose or publish the series-shunt arrangement in the description which I have already quoted. They find Varley's description to be inconsistent with series-shunt and suggestive of something quite different. The value of these opinions, however, is seriously diminished when consideration is given to the method by which they are reached. I think I do the defenders' witnesses no injustice when I say that their method is to take Varley's description paragraph by paragraph each by itself and detached from the context, and then proceed to show how each separate paragraph is, when so read, inconsistent with, or suggestive of something other than series-shunt. As an example of this method of dealing with Varley's description, I may refer to the evidence of Prof. Silvanus Thompson, the first witness examined by the defenders. Such a method is neither reasonable nor fair. To do justice to Varley's description it must be read in its entirety, and when this is done even Mr. Thompson has to admit, as he does on cross-examination, that the description is "consistent with the series-shunt arrangement, which is just a somewhat guarded way of saying that it is descriptive of a series-shunt arrangement. In like manner (but with a greater degree of fairness) Sir William Thomson deals with the description. He finds that there are some things inconsistent with series-shunt, that he "has been puzzled" in trying to understand the description which contains some words of a misleading rather than instructive tendency, and he concludes that an ordinary skilled workman would not in 1876 by Varley's description "have had disclosed to him the system of series-shunt winding." That opinion certainly undergoes modification in the course of his examination, for he concludes his evidence in chief (on this part of the case) by saying that he thinks "it quite probable that in 1876 he (the ordinary skilled workman) might have been led to series-shunt by these descriptions." His cross-examination, however, brings him still nearer to the view which I have taken. He says: "The whole passage is consistent with series-shunt winding except the partial inconsistency of the first lines, which is not an absolute inconsistency." On the whole, I think Sir William Thomson may fairly be claimed by the pursuers as a witness in support of their views.

A great deal of evidence is adduced to show that Varley's description would not have enabled an ordinary skilled workman to construct a series-shunt machine, although some of the defenders' witnesses say that from Varley's description it would have been difficult only, not impossible. But assuming the fact to be that from Varley's description alone the ordinary skilled workman could not have constructed a series-shunt machine, that is by no means conclusive of the question in the defenders' favour. A specification may so insufficiently describe the process or the machine patented as to render the patent invalid. It may, nevertheless, contain sufficient description to disclose or publish the invention so as to prevent its being validly patented by another subsequently. But I think it has been demonstrated that Varley's description was sufficient to enable a workman to make his machine. The model, No. 37, which everyone admits to be a model of a series-shunt wound machine, was made by a lad 19 years of age, apprenticed to an instrument maker, "from the information derived from Varley's patent with its drawings, and from nothing else." "It is entirely my own idea of Varley's patent." The same things was done by others. On the other hand, while there are witnesses brought to say that the description is misleading and inconsistent, no skilled workman has been brought to prove that having tried to make the machine from Varley's description he had been unable to do so.

It is further urged by the defenders that Varley had not when he invented his machine any knowledge of the value of series-shunt, and particularly of the quality of "constant potential," which by a series-shunt machine alone of the three I have mentioned can be approximately obtained ; that series-shunt was not in his mind, but some method of series-winding with a separate coil for separate excitation ; that, on the other hand, Brush knew the value of and was seeking to find a self-regulating machine. These matters have not, in my mind, any very direct bearing on the question at issue, but they require to be noticed. In the first place, Varley depones that in making his specification, he "understood the electrical significance of series-shunt winding," and I believe him. It is only due to Mr. Varley that I should say that, whatever may be the soundness or otherwise of his electrical theories, there is no doubt in my mind of his honesty. When he speaks to facts, I think he may be entirely relied on. In the second place, whatever value Varley placed on the compound winding of his machine, it was not in his view to make a machine which should proceed on the principle of separate excitation within the machine itself. He made a drawing (No. 40 of process) in November, 1876 (before the date of his provisional specification), which shows that he intended his machine to be a series-shunt, and not a series with separate excitation. With regard to that drawing, Prof. Silvanus Thompson says : "So far as that drawing goes, it indicates a series-shunt arrangement." In the third place, without expressing any opinion as to what may have been the state of knowledge of either Varley or Brush before 1876 or 1878 as to the value or obtainability of "constant potential," it is certain that neither of them in their respective specifications say anything to indicate their appreciation of the value of that quality or disclosed any view whatever as to the mode in which it was to be obtained. Even in 1878 constant potential was not felt to be a desideratum in electrical machines; and in regard to this matter, Varley and Brush, for all that appears, stand on an equal footing.

Lastly, on this branch of the case I have to notice that the defenders rely very much upon the fact that Varley in his specification did not claim the invention of compound winding. But Varley explains why he did not do so, and I have no doubt his explanation is true. Perhaps he was too timid ; perhaps he had given a construction and attributed a value to his brother's communication which it would not bear and did not merit. And yet it appears that another skilled electrician at first reading took the same view of that communication which Varley did. But the fact that Varley did not claim a certain invention is no proof that he did not publish it.

I come now to the question whether the defenders' machine was anticipated by user. A machine was constructed under Varley's specification in 1876 or 1877, which is produced. I think it is proved to be a series-shunt machine. It has the two coils of wire round the magnets, one of greater resistance than the other, and was capable undoubtedly of being worked as a series-shunt, having an appropriate commutator for that purpose. But some of the defenders' witnesses say it was a merely experimental machine, and could be connected in a variety of ways. It was certainly not worked as a series machine with separate excitation, for the commutator used was quite inappropriate to, and negatived, the idea of such use. How was it connected ? Varley says, "The machine No. 29 was connected exactly in the way that is represented by that diagram" (No. 40). Sir William Thomson says that diagram represents series-shunt. He is asked, "If you were told as a fact that this machine had been connected in accordance with the device shown in that sketch, would that convey to your mind a certainty that this machine had been worked as a series-shunt machine ?" And he answers, "Yes." There are other signs spoken to, which in the opinion of some of the witnesses indicate that the machine was worked as a series-shunt—but there are contrary opinions also. I rely upon the evidence of Varley that his machine, which was undoubtedly capable of being connected and worked as a series-shunt, was so connected and worked. He knew best how his machine was connected, and, as I have said, on any matter of fact, I have no doubt of Varley's accuracy and truthfulness. Then if it was so worked it was worked publicly. It was used publicly to illustrate certain operations in a diving-tank, and for the purpose of photographing an ice-machine. These were not experiments on the machine itself. They were the application of the machine to business purposes made in the presence of the public without secrecy or concealment. Very little use of a machine in such circumstances will constitute proper use. "If it is proved distinctly," said Lord Lyndhurst, "that a machine of the same kind was in existence, and was in public use—that is, if use or if trials had been made of it in the eye and in the presence of the public—it is not necessary that it should come down to the time when the patent was granted If it was discontinued, still that is sufficient evidence of the prior use so as to invalidate the letters patent." Such use of Varley's machine is I think distinctly proved.

I am, therefore, of opinion that the defender's machine was antici-

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pated by Varley's, both by publication and user, and that the defender's patent is therefore invalid. I therefore give decree as concluded for, with expense.

CITY NOTES.

Brazilian Submarine Telegraph Company, Limited.—The traffic receipts of this Company, for the week ended June 21, amounted to £2,414.

Eastern Extension Telegraph Company, Limited.—The Directors of this Company have declared an interim dividend of 2s. 6d. per share for the quarter ended March 31 last, payable on the 15th proximo.

Western and Brazilian Telegraph Company, Limited.—This Company's receipts for the week ended June 21, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £1,567.

NEW COMPANIES REGISTERED.

Wolverhampton Electric Light and Power Company, Limited.—Registered by Waterlow Bros. and Layton, Limited, 24 and 25, Birchin-lane, E.C., with a capital of £50,000 in £10 shares. Object: to establish and carry on in Wolverhampton, or within 10 miles thereof, works for the purpose of the production, transmission, storage and use, by any means, and for any purpose of light, heat, electric, magnetic, or other force, and to supply to corporations, companies, firms, persons, or municipal bodies or authorities of any kind, light, heat, or force upon such terms as the Board may at any time think fit. The first subscribers are:

	Shares.
A. Hickman, Wolverhampton	1
C. Wells, Berrington Lodge, Wolverhampton	1
C. F. Mander, Wolverhampton	1
J Sparrow, Springfield, Bilston	1
E. Pritchard, St. Peter's-close, Wolverhampton	1
T. J. Barnett, Tattenhall-road, Wolverhampton	1
S. Glaze, 55, Dudley-street, Wolverhampton	1
L. T. Smith, 22, Darlington-street, Wolverhampton	1
C. Adams, 80, Darlington-street, Wolverhampton	1
G. Stanger, North-street, Wolverhampton	1
T. B. Cope, Queen-square, Wolverhampton	1
O. E. McGregor, Queen-square, Wolverhampton	1
W. Hodson, Compton Hall, Wolverhampton	1
J. Parkes, 9, Parkdale, Wolverhampton	1
W. Evans, 7, Park-road West, Wolverhampton	1
W. L. Rowland, Wolverhampton	1
W. H. Cook, Tettenhall-road, Wolverhampton	1
C. Barlow, Bilston Mill, Wolverhampton	1
A. McBean, 9, Rectory-terrace, Wolverhampton	1
C. Newnham, 10, King-street, Wolverhampton	1
S. Page, Lichfield-street, Wolverhampton	1
T. Parker, Newbridge, Wolverhampton	1
Miss Page, The Poplars, Wolverhampton	1

There shall not be less than three nor more than eight Directors. Qualification, 50 shares. The first are A. Hickman, C. Wells, C. T. Mander, J. E. Sparrow, E. Pritchard, and T. J. Barnett. Remuneration, £300 per annum and 10 per cent. on net profits after 7 per cent. dividend.

Entwistle and Gass, Limited.—Registered by Burton and Co., 37, Lincoln's-inn-fields, W.C., with a capital of £20,000 in £10 shares. Object: to carry on the businesses of mechanical, hydraulic and electrical engineers, machine makers, metallurgists, and manufacturing chemists, etc. The first subscribers are:

	Shares.
H. E. Entwistle, 49, Manchester-road, Bolton	1
W. G. Gass, 118, Manchester-road, Bolton	1
T. J. Gass, 118, Manchester-road, Bolton	1
G. P. Gass, 118, Manchester-road, Bolton	1
Mrs. Entwistle, 42, Manchester-road, Bolton	1
Miss Entwistle, 89, Manchester-road, Bolton	1
Mrs. Chadwick, 19, Ferguson-street, Bolton	1
J. B. Gass, 108, Manchester-road, Bolton	1

H. Entwistle, W. G. Gass, T. J. Gass, and G. P. Gass are appointed first Directors. Qualification: £1,000 stock. Remuneration to be determined in general meeting.

Crompton Electric Supply Company of Australia, Limited. Registered by Deacon and Co., 4, St. Mary-axe, E.C., with a capital of £50,000, in £5 shares. Object: to carry on in the Australasian colonies the business of contractors for the supply of electricity, and for the execution of all work connected therewith. The first subscribers are:

	Shares.
F. T. Medcalf, 4, St. Mary-axe, E.C.	1
E. Kemp, 13, St. Ann's-terrace N.W.	1
T. F. Goddard, 7, Staple-inn, W.C.	1
H. Gibson, 4, St. Mary-axe, E.C.	1
T. H. Fidger, 4, St. Mary-axe, E.C.	1
A. Stuart, 10, Ancona-road, Highbury	1
W. Eawtt, 29, Powell-road, Clapton	1

There shall not be less than three nor more than five Directors. The first are Viscount Torrington, J. F. Allbright, and W. G. Whifferd. Qualification, £200 stock. Messrs. Harrison and Whiffen are appointed managers, with a remuneration of 6 per cent. upon the gross receipts of the Company until in any year the Company's gross receipts exceed £20,000, and a sum equal to 5 per cent. upon the gross receipts over £20,000 and under £40,000, and a sum equal to 4 per cent. upon the gross receipts over £40,000 per annum.

PROVISIONAL PATENTS, 1889.

JUNE 17.

9885. **Improvements in or relating to electrical alarm clocks and indicators.** George Scarlett, 6, Lord-street, Liverpool.

9917. **Improvements in switches used for electrical purposes.** Frederick Baumgart Nicholson, 7, Westminster-chambers, London.

9945. **Improvements in arc lamps.** Luther Hanson, Commercial-street, Halifax, Yorkshire.

9977. **Improvements in electrical reciprocating tools.** William Phillips Thompson, 6, Lord-street, Liverpool. (Harry Norton Marvin, United States.) (Complete specification.)

JUNE 18.

9988. **Improvements in electricity meters.** John Smith Raworth, 46, Lincoln's-inn-fields, London.

9994. **Improvements in apparatus for the manufacture of sugar by electricity.** Elias Maigrot and José Sebates, 53, Chancery-lane, London. (Complete specification.)

9999. **Improvements in the manufacture of insulated electrical conductors and cables.** Edwin Thomas Truman, 55 and 56, Chancery-lane, London.

10061. **Improvements in apparatus for separating gold and other metals from their ores by the aid of electricity.** George Jones Atkins, 115, Cannon-street, London.

JUNE 20.

10082. **Improvements relating to electric switches, fuse blocks, ceiling plates, and the like.** Gustav Binswanger, 20, High Holborn, London.

10102. **Improvements in subterranean conduits for electric wires, &c., which may also be employed for the purposes of pneumatic transmission.** Herbert John Allison, 52, Chancery-lane, London. (Ranald Macdonald, United States.) (Complete specification.)

JUNE 21.

10143. **Improved means for operating electric light switches.** Aloys Louis Vogel, 55 and 56, Chancery-lane, Middlesex.

10155. **Improvements in electric tramcars and locomotives.** John Smith Raworth, 46, Lincoln's-inn-fields, London.

JUNE 22.

10173. **Improvement in stop motion for looms by electricity.** John Vickerman, Salford, Lockwood, Huddersfield.

10209. **Improvements in electrical accumulators or storage batteries.** Johannes Zacharias and Friedrich Marx, 4, South-street, Finsbury, London.

SPECIFICATIONS PUBLISHED

1885.

3379. **Distributing electricity.** Thompson (Zipernowsky and another.) (Second edition.) 1s. 1d.

1888.

10299. **Electric logs.** Wallace (Scott.) 8d.

10627. **Galvanic batteries.** Dopping-Hepenstal. 4d.

10730. **Electric firing gear for guns.** Noble. 8d.

10929. **Magneto-electric generators, &c.** Cox-Walker and Swinton. 8d.

10941. **Lighting trains by electricity.** Timmis. 8d.

1889.

6065. **Electric motors.** Lake (Thomson.) 8d.

6622. **Electrical switches, &c.** Howard and others. 4d.

7002. **Secondary batteries.** Hicks. 6d.

COMPANIES' STOCK AND SHARE LIST.

Dividend.		Name.	Paid.	Price Wednesday
12 Feb.	1/2	Anglo-American Brush E.L.	4	3¾
12 Feb.	2/0	— fully paid	5	4½
14 Nov.	0/4½	Con Telephone & Main ...	1	⅝
27 July	10/0	India Rubber, G. P. & Tel.	10	19½
......	...	House-to-House	4½	4½
30 May	2½%	Oriental Telephone	11	⅓
......	...	London Electric Supply ...	5	3½
......	...	Swan United	3½	3½
12 July	12/0	Telegraph Construction ...	12	42½
2 July	6/0	— 6%, 1889	100	105
29 Nov.	5/0	United Telephone	5	15

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